MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY,

CONTAINING

PAPERS,

ABSTRACTS OF PAPERS,

AND

REPORTS OF THE PROCEEDINGS

OF

THE SOCIETY,

FROM NOVEMBER 1866, *TO JUNE* 1867.

VOL. XXVII.

BEING THE ANNUAL HALF-VOLUME OF THE MEMOIRS AND PROCEEDINGS OF THE ROYAL ASTRONOMICAL SOCIETY.

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MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. XXVII. *November* 9, 1866. No. 1.

Rev. CHARLES PRITCHARD, President, in the Chair.

Wm. Westgarth, Jun., Esq., 5 Hadley Street, Kentish Town;
Rev. J. Maurice Wilson, Rugby School;
Rev. Frank Besant, Stockwell Grammar School;
E. B. Denison, Esq. LL.D. Q.C., 33 Queen Anne Street;
Rev. N. Jennings, Avenue Road, Regent's Park;
George Manners, Esq., Lansdown Road, Croydon; and
Capt. R. M. Parsons, R.E., Ordnance Survey Office, Southampton,

were balloted for and duly elected Fellows of the Society.

On the Mass of Jupiter, as deduced by Herr Krüger from the Observations of Themis. **By W. T. Lynn, Esq.**

The Astronomer Royal having kindly placed in my hands a paper containing an investigation recently made by Herr Krüger of the orbit of *Themis*, with special reference to redetermining the mass of *Jupiter* by the effects its attraction produces on that planet, with a request that I would communicate something of its contents to the Royal Astronomical Society, I very gladly avail myself of this opportunity of doing so. And it appears desirable that I should commence with a brief review of the state of our knowledge with regard to that important element in the solar system, the mass of the planet *Jupiter*, its largest member with the exception of the central luminary itself. What that knowledge was in the year 1832, cannot be more clearly stated than in the words of Mr. Airy,

then Plumian Professor at Cambridge, to the Meeting of the British Association held that year at Oxford. He said, "In the *Berlin Ephemeris* for 1826, Nicolai gave a short paper containing results of great importance deduced from the discussion of observations on *Juno*. In all the calculations hitherto made, the mass adopted for *Jupiter* was either that assumed by Laplace (founded on Pound's observations of the elongations of *Jupiter's* satellites), or that given by Bouvard (from the perturbations of *Saturn*), differing little from the other. Now Nicolai stated that the observations of *Juno* at fifteen oppositions required an increase of about $\frac{1}{80}$th in the mass of *Jupiter;* but that even then the observations could not be well represented; and that he conceived the ***absolute attraction*** of *Jupiter* on *Juno* must be different from that upon the Sun. The last conclusion, attacking one of the most important principles in the theory of gravitation, required further examination. In the *Berlin Memoirs,* 1826, Encke discussed all the observed oppositions (fourteen) of *Vesta*, separating the perturbations produced by *Jupiter* into two parts, one being *Jupiter's* attraction on the Sun and the other *Jupiter's* attraction on *Vesta*, and considering the assumed mass of *Jupiter* in these two attractions as liable to two separate errors. The result was, that the absolute attraction of *Jupiter* on *Vesta* did not differ from that on the Sun by more than $\frac{1}{10000}$th of the whole, and that Nicolai's mass ought to be increased about $\frac{1}{300}$th of the whole. Encke remarks, however, that Nicolai's mass will represent the observations very nearly as well; and Gauss has found the same for *Pallas*. Nicolai's mass is generally adopted by the German astronomers." The mass obtained by Nicolai was $\frac{1}{1053 \cdot 921}$; that by Encke $\frac{1}{1050 \cdot 36}$.

Since the time spoken of in the Report from which I have quoted,* two excellent determinations of *Jupiter's* mass from the motions of his satellites have been made, the first by Airy, the second by Bessel. The observations used by the former were made partly at Cambridge, and partly at Greenwich. The author remarks in the first of his three papers on the subject (*Memoirs of the R. A. S.*, vol. vi., p. 83), that, considering the great importance of the mass of *Jupiter* in both planetary and cometary investigations, "it seems remarkable that no attempts should lately have been made to ascertain the correct value from the readiest of all means, the elongations of his satellites. It is true that the value adopted by Laplace, $\frac{1}{1067 \cdot 09}$ of the Sun's mass, was inferred from observations of the

* It may be mentioned that at the close of that Report, Mr. Airy, amongst other suggestions of points to which attention should be directed, recommends, what he afterwards himself carried out, that new measurements be made of the elongations of *Jupiter's* satellites, especially of those of the fourth.

fourth satellite; but they were observations made by Pound, and of which no account (so far as I know) remains, except the mere statement of numbers in the *Principia*." Mr. Airy concludes, at the end of this paper, that "Nicolai's mass cannot now be admitted, but Encke's mass is nearly as well supported as mine by these observations."

The mass he then determined was $\frac{1}{1048\cdot70}$, a little larger than Encke's; and this, from a discussion of a larger number of observations, he afterwards (*Memoirs*, vol. x. p. 47) still further increased, his final value being $\frac{1}{1046\cdot77}$. This result was communicated to the Society in January 1837. The confirmation afforded to this by the determination of Bessel from his Königsberg observations is very striking. His value is $\frac{1}{1047\cdot87}$, and he remarks in regard to it, in a paper communicated to the French Academy of Sciences (*Comptes Rendus*, 1841), "Je suis enfin parvenu à la connaissance d'un élément d'observation bien important, et j'ose me flatter qu'une erreur plus grande que $\frac{1}{10,000}$ est impossible." He also mentions its close agreement with Airy's value.

In the paper to which I have now the honour of calling the attention of the Society, and which has recently been communicated to the Finnish Society of Sciences, Krüger states that he has been for some time engaged on the theory of *Themis*, "principally in view of the valuable material which that planet must in time afford for the determination of the attraction of *Jupiter*." The opinion has in recent times been expressed by Schubert that Bessel's mass, which, as we have seen, agrees so closely with Airy's, and which is now adopted in nearly all calculations, is in reality further from the truth than the smaller value deduced by Nicolai from the oppositions of *Juno;* his ground for this being, in addition to what he had noticed in his own calculations, the fact that Brünnow, in discussing the motions of *Iris*, had also come to the same result,—a diminution of the mass of *Jupiter* that had been employed.* The point becomes, as Krüger justly remarks, very interesting, since it would seem to involve the question first raised by Nicolai, whether, if the mass of *Jupiter* deduced from the motions of the small planets and from those of his own satellites, differed by any decided amount, it would be necessary to assume the existence of some forces hitherto unknown or imperfections in the application of the theories on which those motions are calculated. It is satisfactory, then, to find that the result of his elaborate investigation is, that, instead of diminishing Bessel's value of the mass of *Jupiter*, it ought really to

* Schubert's remarks on the subject are contained in *Ast. Nach.*, No. 1562.

be increased by the $\frac{68}{100,000}$th part of its value,—a quantity so small that we may regard it as tending to the complete confirmation of that mass. I will endeavour to give the Society a sketch of the way in which Krüger has treated the observations.

The method pursued is Encke's method of mechanical quadratures; and he begins by remarking that, with whatever accuracy the calculation may be made, the decimal figures which are not included must, or at least may, induce small errors in the perturbations of the co-ordinates and their differential quotients, which errors will go on increasing with the time: nor is this affected by the transition to new osculating elements. Thus the method will cease to be sufficiently accurate if long intervals of time are taken into account. But the errors induced are essentially diminished if the investigation be conducted by means of well-selected polar co-ordinates. "I have, as yet, however," says the author, "deviated in no respect from Encke's method, partly from unwillingness to interrupt calculations once begun, and partly that I might not lose the advantage of the convenient and time-saving co-ordinate tables now published. But should a repetition of the calculation of the perturbations hereafter appear desirable, I think that I should then feel bound to give the preference to the method of polar co-ordinates."

He adds that the investigation of the absolute perturbations would, if performed with the degree of accuracy necessary to draw conclusions concerning the mass of the disturbing planet, be an excessively laborious and tedious operation.

He sets out from a set of elements for *Themis* in 1853, and uses perturbing forces for *Jupiter* and *Saturn* (the effects due to each planet being simultaneously calculated and combined throughout) derived from Bessel's values of the masses of those planets. In the mechanical quadrature, the calculation was extended to the ninth decimal. A new set of elements was deduced, which, even for the last oppositions in 1864 and 1865, furnish places differing by not more than about one second of time from those observed. Continuing the calculation of the perturbations, the author made use of the co-ordinate tables which, since 1858, have been communicated in the *Astronomische Nachrichten*, and obtained new osculating elements for 1864. Krüger then compares places derived from the sets of elements he has obtained with observed places taken from the *Astronomische Nachrichten* and our *Monthly Notices*, referring the normal places to the ecliptic on account of the small inclination of the planet, and proceeds to show how he has calculated a co-efficient for the improvement of the mass of *Jupiter*. "All the perturbations," he says, "previously given, refer to the united influence of *Jupiter* and *Saturn*. But since the attraction of the latter, as is known *à priori*, can only be insignificant, and particularly

in the case before us, can only amount to a small fraction of that of *Jupiter*, it will be allowed that the correction-factor for determining the perturbations from the longitude-equations must be regarded as referring to the mass of *Jupiter* alone, because, owing to its smallness, its multiplication into the perturbations of *Saturn* can only give imperceptibly small quantities." The author feels bound to consider also the perturbations produced by *Mars*, although it is easy to show that that planet has but a trifling effect on the motions of *Themis*, yet, owing to the near commensurability of their mean motions, there arises a perturbation-term of long period, which in so short a time as twelve years, is insignificant, but in a longer interval would have to be taken into account. With the exception of some places in 1860, derived from observations made at Berlin, and which Krüger thinks are affected by some error in the elements of the very faint stars of comparison made use of, the agreement he obtains between the calculated and observed places is very close. The uncertainty in those places cannot appreciably affect his final result which I have previously mentioned, "*that the observations of Themis require an augmentation of Bessel's mass of Jupiter, amounting to the* $\frac{68}{100000}$*th part of its value.*" This gives for the actual mass of *Jupiter* compared with the Sun, the fraction $\frac{1}{1047 \cdot 158}$, almost exactly equal to the mean of the values determined by Airy and Bessel from the motions of the satellites.

Observations of the New Variable T *Coronæ.*
By J. Baxendell, Esq.

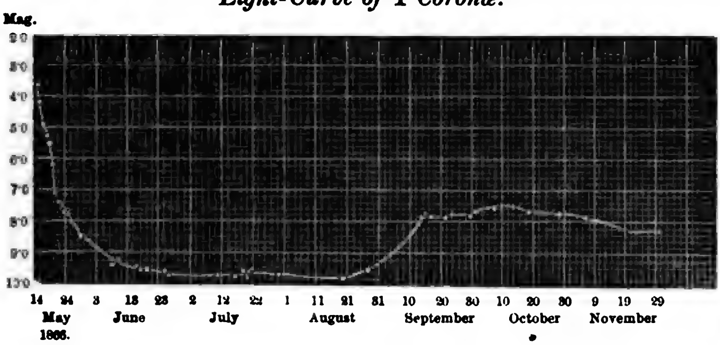
Since Mr. Huggins communicated my early observations of this star to the Society (*Monthly Notices*, vol. xxvi. p. 277), I have observed it as often as the state of the weather and other circumstances would permit; and having lately carefully re-determined the magnitudes of the stars with which I have compared it during its changes, and made a fresh reduction of all my observations, I now submit the results to the Society, believing that a projection of the entire series will give as correct a representation of the course of the star's changes up to the present time as can well be obtained. All the observations after the star became invisible to the naked eye were, with only three exceptions, made at Mr. Worthington's Observatory with his equatoreally mounted achromatic of 5 inches aperture, and always with the same eyepiece, a positive, having a magnifying power of 68 times.

In the scale of magnitudes which I have employed the

light-ratio is 2·512; it will, therefore, be easy to calculate the relative intensities of the star's light at different times, and thus obtain an estimate of the degree of reliance to be placed upon the results of observations made with the spectroscope.

From the following results it will be seen that for several days after my first observation the brightness of the star diminished with great rapidity, and afterwards more gradually, and that on the 26th of June it had sunk to the 9·7 magnitude. It then remained with little change till about the 20th of August, when another rise commenced, and on the 15th of September it had attained the 7·8 magnitude. On the 10th and 14th of October it was of the 7·5 magnitude, and since the latter date its brightness has again slightly diminished.

Light-Curve of T *Coronæ.*



Observations of T *Coronæ.*

Date. 1866.	Mag.	Colour, &c.
May 15	3·7	White, with a very slight yellow tinge; whiter than ι.
16	4·2	Cream-coloured, but the light very bright and star well-defined, without any hazy appearance.
17	4·9	With naked eye, cream-coloured; exactly similar to ι.
	5·1	With 5 in *Ach.* p. 68.
18	5·3	Cream-coloured or buff; at times I have an impression of a blue tinge, as if the yellow of the star were seen through a film of a blue tint.
19	5·6	Deep cream, buff, bath-brick, or wash-leather colour, with a tinge of blue over it. ι the same colour, but perhaps slightly lighter, and without the blue, or at least with excessively little of it. Repeatedly examined also by Mr. Dancer and Mr. Williamson with different powers, and their estimations of colour precisely the same as my own.

Date. 1866.	Mag.	Colour, &c.
May 20	6·2	Buff-coloured, with a tinge of blue, and deeper than ε *Coronæ*, which is yellow or light buff.
21	7·1	Leaden, or slaty blue; the yellow colour has almost entirely disappeared.
22	7·4	The light of the star is dull, and is of a slaty blue or dark French-white colour, or nearly like Smyth's No. 4, blue. No trace of yellow or red can be clearly made out.
23	7·5	Dull grey or French white. Sometimes there seems to be a trace of yellow.
24	7·7	Dull white, with a slight tinge of yellow or orange.
25	7·8	Dull, and slightly orange-white. A shade of blue sometimes suspected.
26	8·0	Dull orange white.
29	8·4	Dull orange yellow.
June 8	9·3	Dull orange yellow.
10	9·2	Dull orange yellow.
16	9·4	
17	9·5	
19	9·5	
25	9·6	Orange yellow.
26	9·7	Orange.
July 11	9·7	Dull yellow.
16	9·7	
19	9·6	
20	9·7	
21	9·6	
22	9·5	Dull pale orange.
30	9·7	Orange yellow.
Aug. 20	9·8	
27	9·5	
31	9·3	Dull yellow.
Sept. 14	7·9	Dull yellow; almost exactly Smyth's No. 3 yellow.
15	7·8	Yellow.
17	7·9	Pretty bright yellow.
22	7·9	
24	7·8	Yellow
30	7·8	
Oct. 1	7·7	
[illegible]	7·6	Greyish yellow

Date. 1866.	Mag.	Colour, &c.
Oct. 8	7·6	
10	7·5	Yellow.
14	7·5	Light yellow.
19	7·7	Light yellow.
28	7·8	Yellow.
Nov. 6	7·9	Smyth's orange No. 4.

It will be noticed that in the recent observations no mention is made of the blue tinge which formed so striking a feature for some time after the star's first appearance.

I may state that on the night of the 7th of May I observed all the naked-eye Variables then visible, and also several of the telescopic ones; and, among the latter, two in the constellation *Corona*, but this star, if at that time really visible, entirely escaped my notice. The nights between the 7th and 15th were cloudy at Manchester; but on the latter date the sky being very clear, the new star at once arrested my attention on proceeding to make my usual observations of the naked-eye Variables.

Cheetham Hill, Manchester,
Nov. 8, 1866.

On the Identity of the variable T *Coronæ with a Star contained in Wollaston's Catalogue.* By E. J. Stone, Esq.

In the *Monthly Notices*, vol. xxvi. No. 8, will be found an extract from a letter of Mr. Graham's, in which attention is drawn to a supposed observation of a system near T *Coronæ* in Wollaston's Catalogue. In that Catalogue, Zone 63° N.P.D. will be found the following observation:—

$$\text{R.A. } 15^{h}\ 51^{m} \pm \qquad \text{N.P.D. } 63^{\circ}\ 29' \pm$$

"Double (Hers. v. 75), v.v. uneq....dist. 41″ 12‴...pos. 16° s.f. It is really quadruple, for the small star is double, and there is a still smaller at about 40° s.p. the small ones."

The epoch of Wollaston's Catalogue is Jan. 1, 1790. If we bring up the place of this system to the year 1866 we obtain:—

$$\text{R.A. } 15^{h}\ 54^{m} \pm \qquad \text{N.P.D. } 63^{\circ}\ 41' \pm$$

The place of the variable T *Coronæ* for the same epoch is—

$$\text{R.A. } 15^{h}\ 54^{m}\ 53^{s}\!\cdot\!8 \qquad \text{N.P.D. } 63^{\circ}\ 41'\ 52''\!\cdot\!9.$$

The position of Wollaston's system appears, therefore, to be nearly identical with that of the variable T *Coronæ*. If we could rely upon Wollaston's observation it would be a most interesting speculation, whether the late intense brightness of T *Coronæ* was not due to the falling of one or more of the components of this system into the central sun. However, on referring to Wollaston's authority, Herschel,* we find as follows:—

"Double. About 1 degree S. following ε, in a line parallel to θ and ε *Coronæ*; the preceding of three forming an arch. Extremely unequal. r. l.; s. darker r. Distance 41″ 12‴. Position 16°·0′ S. following."

If we take Sir W. Herschel's description of the position of his double star, viz. "1 degree S. following, in a line parallel to θ and ε *Coronæ*," we shall find that the star 2767 of Argelander's Zone + 26° agrees very closely with Sir W. Herschel's description of place. This star is also "the preceding of three forming an arch." It is double: the relative positions of the components agree closely with those assigned by Herschel. I believe, therefore, that this is Herschel's system.

This paper of Sir W. Herschel's was read before the Royal Society, December 9, 1784. Wollaston's Catalogue was published 1789.

I am unable to find any authority for Wollaston's statement that the system is really quadruple. Wollaston's optical means were hardly sufficient to supply omissions on the part of Sir W. Herschel. I cannot help thinking, therefore, that we have unfortunately some confusion or mistake on Wollaston's part, with reference to this observation, and that the ground is too unsafe for speculation.

A Description of some Apparatus employed in the Adjustment of Sextants. By William Simms, Esq.

Considering that the adjustment of the Sextant has lately occupied the attention of some of the Members of the Royal Astronomical Society, I beg to present a short statement of what has been attempted by myself in this direction.

Several years since, in consequence of a prolonged absence of clear weather, I was compelled to direct my attention towards finding some substitute for the Sun's disk in effecting the various adjustments of the instrument.

For the purpose of obtaining the index error, and adjusting the dark shades, I temporarily fitted up a telescope of about 2½

* Hers. v. 75, July 18, 1782, *Phil. Trans.* 1785, p. 109.

inches aperture, preferring this to a pair of telescopes, for the reason that the distance between the centre of the index-glass and the axis of the telescope varies greatly in different instruments; in the focus of the object-glass there was fixed an opaque diaphragm, with a clean circular aperture subtending an angle of ½ degree approximately, thus representing, when viewed through the sextant telescope, an image of the Sun; it is evident that the object-glass must be perfectly corrected for spherical aberration, and that the diaphragm must be carefully adjusted to the focus of parallel rays.

I had contemplated the employment of a pair of small telescopes with their optical axes parallel, but seeing that the apertures must be sufficiently large to allow of sextants which differ in the distance between the telescope and the index-glass being brought to view them, and that the parallelism must be adjusted by another instrument, I determined to adopt the single object-glass of large aperture.

I found no difficulty in adjusting the lighter shades, but the darkest baffled me at that time. I think that, with some of the intense lights now available, a sufficient degree of illumination might be obtained to correct the darkest shades of the sextant. The return of bright weather and less pressure of business induced me to lay aside my contrivance, and to look again to the Sun; and I should, if possessing the most perfect collimating apparatus, prefer this luminary for obtaining both index-error and errors of the shades.

Now I have another contrivance to describe, which I have found so useful that I have retained it ever since it was fitted up. This consists of two small telescopes, fixed at an angle of 90 degrees upon an arc of cast-iron, which is set up vertically, being held at the centre of gravity to avoid any strain from expansion; the diaphragm in the focus of each object-glass is an opaque one, with a circular aperture of ½ degree, as before described, and the observation is effected by making contacts on both sides of the images precisely as when observing two images of the Sun; this gives a very convenient and accurate means of setting the optical axis of the sextant telescope parallel to the limb; and having ascertained by observation with a Troughton reflecting circle the true angle subtended by the collimating telescopes, I have at the same time the error of the arc of the sextant for 90 degrees, and a check upon the centering of the instrument.

Charlton, Nov. 6, 1866.

Some Remarks upon Professor Kaiser's Investigation of the Errors of a Double-image Micrometer. By William Simms, Esq.

The attention of the Royal Astronomical Society having lately been called to the consideration of the double-image Micrometer by Professor Kaiser, in two communications which have appeared in the *Monthly Notices*, I have been induced to offer a few remarks upon the subject.

In a paper which was read at the Meeting on March 9 last, the Professor has named three sources of error which he detected in the course of his investigations; and here I must beg to be allowed to express my admiration of the amount of ingenuity and perseverance manifested in these researches, and I can fully realise his mortification at the loss of his testing marks after expending so much time upon the observations, having myself been surprised by finding a blank where my marks had previously existed.

Now with regard to the first-named error to be feared.

1. Periodical errors of the micrometer screw.

From the results given in the table at page 195, vol. xxvi. I imagine that the screw has sustained some injury; this might possibly have occurred in the transmission of the instrument abroad (the Professor would not have expended so much time and patience upon an object which he could suspect of having met with an accident); these periodical errors manifest themselves in a manner that would indicate a slight flexure of the screw; it is certain that, as these screws are cut in a very delicate engine, such errors ought not to exist, and the results of the investigations by the Astronomer Royal upon the twin screws of the Reflex Zenith Micrometer show that screws can be made which possess scarcely any sensible inequality.

2. Variability in the mutual distance of the threads of the screw.

This should also be nearly an insensible quantity, but if my surmise of an accidental flexure having occurred should prove correct there would certainly be this error introduced.

3. Distortion of the images.

The Professor has devoted his principal attention to the value of the micrometer scale for different angular distances; now the very numerous observations clearly indicate that the increase in the value of a revolution of the screw with the size of the measured angle is dependent upon the spherical aberration of the concave lens; the converging pencil of light from the object-glass is brought to a very minute disk upon this divided lens, and as one-half of the lens is carried across this point by the screw, it is evident that the resultant image is formed by successive portions of the lens, more and more removed from its centre, and is accordingly influenced by the error arising from its aberration. It will be found at page 202

that the value of a revolution of the screw increases more slowly after a certain degree of separation of the images has been attained; this circumstance appears to perplex the Professor, since he calls special attention to it. I can account for it by supposing that there may be a slight flattening of the curvature of the lens towards its edge, in fact, an approach to the hyperbolic curve; were it possible to make a single lens free from aberration, or to apply a corrected lens here, a perfect screw would give an equal scale to the micrometer. The Astronomer Royal suggested that one-half of the divided lens should be fixed for the sake of simplicity of construction. Those made previously had both segments movable equally in opposite directions by a right and left-handed screw, which were acted upon by a single micrometer head. Professor Kaiser's proposition of making each segment movable by a separate screw would enable the observer to distinguish the error of screw from that introduced by the form of the lens, and give great facility in the investigations which appear to be necessary to give the instrument the minute accuracy which he certainly has shown to be attainable. I think that a scale of equal parts might be applied in the focus of the eye-piece for the purpose of obtaining the instrumental errors; probably a series of notches cut in the edge of a thin piece of metal by a fine screw (like the comb in a reading micrometer), if carefully made, would give a good result; but I do not think any method could compete in accuracy with the very rigorous ordeal adopted by Professor Kaiser.

Charlton, Nov. 2, 1866.

Note by Messrs. De La Rue, Stewart, and Loewy, on the Distribution of Solar-spotted Area in Heliographic Latitude.

In a paper which is now being printed, and which forms the second series of our Researches on Solar Physics, we have investigated the relation between solar activity and the ecliptical longitude of the planets; and as a result we believe that we have discovered a connexion between the behaviour of sun-spots and the longitudes of *Venus* and *Jupiter*.

We have under consideration another branch of this research, which, however, cannot be completed for some time; but, as the results already obtained seem to be of interest at the present moment, we venture to lay them before the Royal Astronomical Society.

Mr. Carrington, it is well known, has given, in his most interesting volume on the Sun, a diagram exhibiting the distribution in heliographic latitude of sun-spots from time to time. Now, if *Venus* and *Jupiter* have an influence on solar activity, it might reasonably be conjectured that, when these

planets crossed the solar equator, the solar activity would be more confined to the equatoreal regions of the Sun, and that when they were furthest removed from the solar equator this activity would extend outwards towards the solar poles.

It appears to us that in Carrington's diagram there is probably evidence of an action of this kind due to both of these planets; and in the table which accompanies this note, and which has been derived in a general manner from Carrington's diagram, it will be seen how closely the minor epochs of solar activity in their approach to the equator agree with the epochs at which *Venus* crosses the solar equator, and how the solar activity spreads out towards the poles at those times when *Venus* is farthest removed from the solar equator.*

The influence of *Jupiter* and a more searching investigation into that of *Venus* will occupy our earliest attention.

It will be seen from a late circular of M. Chacornac that he has drawn attention to Carrington's curve of latitude and to the minor sinuosities, without however giving the above explanation.

Lastly, we may state that we are led by our investigations to the conclusion that solar activity, as shown in the phenomena of sun-spots, would not exist but for planetary motion any more than certain physical phenomena of the planets would be produced without solar influence.

October 30, 1866.

Times of Nearest Approach of Venus to the Solar Equator, and of crossing it.

1	1854	Between	January	5	and	January	10
2		,,	April	26	,,	May	1
3		,,	August	17	,,	August	23
4		,,	December	6	,,	December	12
5	1855	,,	March	30	,,	April	4
6		,,	July	20	,,	July	24
7		,,	November	10	,,	November	14
8	1856	,,	February	29	,,	March	5
9		,,	June	22	,,	June	26
10		,,	October	11	,,	October	16
11	1857	,,	February	1	,,	February	6
12		,,	May	24	,,	May	28
13		,,	September	14	,,	September	19
14	1858	,,	January	4	,,	January	8
15		,,	April	27	,,	May	1
16		,,	August	16	,,	August	21
17		,,	December	7	,,	December	12

* A chart accompanied this notice, which will be printed in the series of papers in course of publication by the Authors.

18	1859	Between	March	29	and	April	2
19		„	July	20	„	July	25
20		„	November	8	„	November	13
21	1860	„	March	1	„	March	5
22		„	June	20	„	June	25
23		„	October	11	„	October	16
24	1861	„	January	31	„	February	4

On the Solar Eclipse of October 8, 1866.
By John Joynson, Esq.

(*Communicated by John F. Stanistreet, F.R.A.S.*)

The partial eclipse of the Sun was observed here to-day under favourable circumstances, for although there was a considerable amount of damp and haze in the atmosphere, owing to the light easterly wind, the sky was almost entirely free from cloud, so that the progress of the Moon over the Sun's disk could be continuously watched from the first contact of the limbs until the Sun was nearly down on the horizon.

The observation, made with a 3½-inch lens and a power of 60, resulted in getting the time of first contact of limbs at $4^h\ 19^m\ 4^s{\cdot}7$, Mean Time at Greenwich, which is somewhat later than the calculated time for this place, but which, it is believed, may be depended upon as not later than the absolute time of contact more than two or three seconds.

The time was taken by the aid of a sidereal chronometer; the error of which was determined by the transit of γ *Draconis* and ζ *Aquilæ*.

Waterloo, 8 *October*, 1866;

Geocentric Lat. $53^\circ\ 17'\ 24''$ N.
Longitude $3\ \ 1\ \ 44$ W.

On the Solar Eclipse of October 8, 1866.
By C. G. Talmage, Esq.

The afternoon was all that could be desired for the observing this Eclipse, not a cloud was in the sky, though, from the prevalence of an easterly wind and the great South Declination of the Sun, the limbs boiled violently.

As the body of the Sun became obscured the light changed in colour in a very marked manner; and at the greatest phase visible here, the light was quite of a reddish-yellow tinge. The time of the first contact was observed with the full aperture of

10 inches, using a diagonal eye-piece. The Moon's limb was exceedingly irregular, boiling considerably.

Leyton Mean Time of First Contact, $4^h\ 26^m\ 28^s{\cdot}29$.

Meteorological Observations.

	Barom.	Attach. Therm.	Wet Bulb.	Dry Bulb.
h m	in.	°		
At 4 0 =	30·362	60	55·5	60·8
4 30 =	30·358	60	53·5	56·5
5 0 =	30·350	59		

A black bulb thermometer in the Sun registered 65°·0 at sunset.

Mr. Barclay's Observatory,
Leyton, Essex.

Minor Planet (89).

Discovered by M. Stephan, Director of the Observatory of Marseilles, August 6, 1866.

The following Elements, calculated by Herr Knorr, from observations, August 7, at Paris, and September 2 and 26, at Berlin, are given in the *Astronomische Nachrichten:*—

Epoch, 1866, Sept. 0·0, Berlin Mean Time.

$$\begin{aligned} M &= 337^\circ\ 27'\ 49''{\cdot}0 \\ \pi - \Omega &= 41\ 46\ 57{\cdot}2 \\ \Omega &= 311\ 29\ 37{\cdot}5 \\ i &= 16\ 11\ 25{\cdot}3 \\ \phi &= 10\ 23\ 14{\cdot}9 \\ \log a &= 0{\cdot}406512 \\ \mu &= 871''{\cdot}444 \end{aligned}$$

($\pi - \Omega$, Ω, i: Mean Equinox 1866·0)

Minor Planet (90) *Antiope.*

Discovered by Dr. Luther, Oct. 1, at $10\frac{1}{2}$ in the evening, by the aid of a Chart constructed by himself.

It was seen as of the 11th magnitude,

R.A.	Decl.
$2^\circ\ 22'\ 0''{\cdot}8$	$-2^\circ\ 31'\ 16''{\cdot}6$
$= 0^h\ 9^m\ 28^s{\cdot}05$	

Mean Motion in R.A. $-\ 44^s$ Decl. $-\ 4'{\cdot}2$

The following set of Elements, calculated by Dr. Tietjen, from observations at Berlin, October 2, 10, and 28, are given in the *Astronomische Nachrichten*, No. 1613:—

1866, Oct. 18·0 Berlin M.T.

$$
\left.
\begin{array}{lcl}
M & = & 40^{\circ}\ 9'\ 55''.7 \\
\pi & = & 243\ 23\ \ 3.0 \\
\Omega & = & 71\ 17\ 24.5 \\
i & = & 2\ 15\ 49.2 \\
\varphi & = & 8\ 29\ 31.4 \\
\mu & = & 644''.196 \\
\log a & = & 0.493993
\end{array}
\right.
\quad \pi, \Omega, i:\ 1866.0.
$$

Johnson Memorial Prize.

All Essays in competition for the Johnson Memorial Prize on the subject proposed by the Trustees in March 1865, as stated in the *Monthly Notices* for that month (vol. xxv. p. 175), namely, "A Discussion of Recent Investigations relating to Star Parallax," must be sent in to the Registrar of the University of Oxford, on or before the 31st of March, 1867.

The Catalogue of the Society's Library, as drawn up in the year 1850, together with the subsequent Annual Supplements to June 1866, bound together in an 8vo. volume, may be had by Fellows, at the price of *2s. 6d.*

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L. J. Hale

MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. XXVII. *December* 14, 1866. No. 2.

Rev. CHARLES PRITCHARD, President, in the Chair.

Radiant Point of the November Meteors, 1866. By A. S. Herschel, B.A.

The importance of attempting to fix the apparent direction of motion of the meteoric bodies seen in England on the morning of the 14th of November, 1866, is best proved by the remarkable coincidence between the observations taken with this object in view, at a number of widely separated places,—each station giving an independent result, and all conspiring to place the Radiant Point near a particular spot of the ecliptic, termed by Herrick the "tangential region" of the ecliptic, and by Mr. Pritchard "the apex of the Earth's way," or the point towards which the Earth was moving at the moment. The longitude of this point of the ecliptic at the time of the maximum display (Nov. 13, 13^h 15^m G.M.T.) was 142° 10′·9, or 89° 17′·5 behind the longitude of the Sun.

For the observations in the following list I am mainly indebted to correspondents furnishing me with results on behalf of the Luminous Meteor Committee of the British As-

sociation. The records of three other observers are included; the notes at the end of the table refer the reader to the original sources from which these observations were derived.

A few words of explanation will suffice to indicate the method of procedure followed in special cases, by which the data were arranged in their present tabular form.

In Nos. 2, 3, 5, 6, 8, 9, 10, 11, the place of the radiant point is generally recorded by the intersection of certain alignments between particular stars in the constellation *Leo*. The corresponding right ascensions and declinations, in these cases, were taken out *from the intersection of straight lines* in the figure of the constellation *Leo*, contained in the Useful Knowledge Society's Atlas of six large charts, on the gnomonic projection, edited by the late Sir John Lubbock, Bart. These maps are ruled with meridians and with circles of declination at intervals of one degree, whence the radiant point thus indicated might be taken out correctly within 5′ of arc.* The places being thus found, and all of them being very near together, 22′ was added to the right ascensions, as a general correction, and 7′ was subtracted from the declinations for precession, since the date (1840·0) of the Atlas.

Among the rest (Nos. 1, 7, 12, 13, 14, 15), with one exception (No. 4), the place of the radiant point is given originally in hours, degrees, and minutes of right ascension and declination. Sir John Herschel gives the ecliptic longitude and latitude in degrees and minutes of a degree, from which the apparent right ascension and declination of the Radiant Point was calculated. These values, and those obtained from the former alineations, are together entered in the fourth and fifth columns of the table, with the connected place of observation, the observer's name, and reference number, in the previous columns.

The ecliptic longitude and latitude of No. 12, deduced from the place of the radiant point observed at Manchester, is that calculated by Mr. J. Baxendell, in his interesting account of the phenomenon, to which reference is made at the end of this paper. But, with the exception of the observations of Sir J. Herschel and Mr. Baxendell (Nos. 4 and 12), the whole of the remaining longitudes and latitudes contained in the last two columns of the table, are freshly computed from the observed right ascensions and declinations of the radiant points, assuming $23^\circ\ 28'$ as the obliquity of the ecliptic.

It deserves to be noticed that of all the observations, Nos. 9, 10, and 11, are the most discordant, in which the position of

* The place of the radiant point assigned by Mr. Pritchard ("the least bit above *x Leonis* of Bode") has, necessarily, been somewhat arbitrarily assumed, in placing the observation among the list, as 1° from *x Leonis*, towards *μ Leonis*.

the radiant point is stated to have been observed at or very near to the stars ζ and γ of the constellation *Leo*. The remaining twelve observed places are situated within an area bounded by a circle of less than 3° in angular diameter. The centre of the circle is in latitude +10° 27′·1, and longitude +142° 34′·9, a position 0° 24′, or less than half a degree of longitude, in advance of the longitude of "the apex of the Earth's way."

List of the Observed Places of the Radiant Point of the Meteors, 1866, November 13.

Ref. No.	Observer.	Place of Observation.	R.A. ° ′	N. Decl. ° ′	Long. ° ′	N. Lat. ° ′
1	T. Crumplen	London	147 0	24 0	141 6	10 5
2	H. Macleod	London	148 57	24 18	142 41	10 58
3	F. C. Penrose	Wimbledon	148 44	22 33	143 7	9 16
4	J.F.W. Herschel	Hawkhurst	148 9	23 48	142 10	10 15
5	C. Pritchard	Freshwater	148 17	23 18	142 28	9 49
6	G. F. Burder	Clifton	150 40	22 45	144 45	10 4
7	W. H. Wood	Birmingham	148 0	25 0	141 37	11 19
8	D. Smith	Birmingham	149 12	22 37	143 31	9 28
9	E. J. Lowe	Beeston Observatory	147 17	23 15	141 36	9 27
10	S. H. Miller	Wisbeach	152 42	22 19	146 41	10 20
11	R. P. Greg	Manchester	152 18	24 6	145 40	11 52
12	J. Baxendell	Manchester	149 33	22 57·5	143 41	9 54·5
13	T.W. Backhouse	Sunderland	149 7·5	23 15	143 12	10 3
14	R. Grant	Glasgow Observatory	148 33	22 30	142 58	9 9
15	A. S. Herschel	Glasgow Observatory	149 0	24 0	142 51	10 42

References.

No. 6. The *Times*, Nov. 15th, 1866.

No. 8. The *Birmingham Daily Post*, Nov. 15th, 1866, (reprinted for private circulation.)

No. 12. *Proc. Manch. Lit. and Phil. Society*, Nov. 27th, 1866, vol. vi., p. 31.

On the Meteoric Shower of 1866, *Nov.* 13–14. By Sir J. F. W. Herschel, Bart.

During the superb display of meteors on the night of the 13th inst. my attention was particularly directed to the determination of the exact situation in the heavens of the Radiant

Point of their courses, which has been commonly stated to be coincident with that of the bright star γ *Leonis*. This, however, was certainly not the case; and I am enabled to say with perfect confidence that their courses diverged, with a very remarkable degree of agreement, from a point considerably higher in declination and less advanced in Right Ascension—nearly intermediate between ζ and ι, but a little below their line of junction, and somewhat above the place of the star marked x in Bode's Chart. Having fixed this point well in my recollection, on laying down its place on that chart next morning, I find its longitude for $1866\frac{3}{4}$ (allowing $55'$ for precession since 1801, the epoch of the chart) to be $142^\circ\ 20'$ and its latitude $10^\circ\ 15'$ north. Several circumstances enabled me to fix on this point with full assurance of its being the true Radiant: first, The frequent out-shooting from a very near proximity to it, and once in several different directions, of a volley of meteors; secondly, On two or three distinct occasions a meteor appeared in this very point, and in all these cases it was motionless, devoid of a train, and on its extinction left only a small nebulous light to mark the place of its appearance; thirdly, On one occasion a meteor shot forth horizontally at a distance of about 6 or 8 degrees from the radiant, and disappeared after running a very short course, leaving a vaporous train which continued visible (fading gradually away); for $2^m\ 40^s$, this afforded time for tracing back the direction of the train (which did not alter), and its course, continued, passed through the spot in question.

The longitude of the Earth, as seen from the Sun at midnight of the 13th, was $51^\circ\ 25'$, which subtracted from $142^\circ\ 10'$, leaves $90^\circ\ 45'$, whereas, were γ *Leonis* the radiant, the difference would have been $96^\circ\ 10'$, indicating an angle of $6^\circ\ 10'$ between the tangent to the Earth's orbit and that of the orbit of the meteors projected on the ecliptic, while the actual small angle so included, of $0^\circ\ 45'$ only, indicates a very near (*possibly* an exact) coincidence of direction. Hence we are constrained to conclude that the true line of direction in space of each meteor's flight lay in a plane at right angles to the Earth's radius vector at the moment; and that therefore, except in the improbable assumption that the meteor was at that moment *in perihelio* or *in aphelio*, its orbit would not deviate greatly from the circular form. The absolute velocity in space of the meteors would therefore be nearly that of the Earth; and from this it appears to follow of necessity that the direction of their revolution must be retrograde. Were it direct, the relative motion parallel to the ecliptic would be *nil*, and the only effective cause of apparent motion would be the meteor's resolved velocity perpendicular to the ecliptic, which would produce a radiant in the pole of the Ecliptic.

In point of fact the elevation of the radiant above the ecliptic was only $10^\circ\ 15'$, and as the *relative* velocity of the

meteors in a direction parallel to the latter plane must have been twice the Earth's absolute velocity, it follows that, had the Earth stood still, the *then* apparent radiant would have had very nearly *double* that elevation (more correctly, 19° 53′), which is therefore the inclination to the Ecliptic of the meteoric orbits.

How far this conclusion of a retrograde motion of the meteorite's revolution round the Sun,—a conclusion already, I believe, arrived at by Mr. Newton, is compatible with the truth of the "Nebular hypothesis," we may leave it to the advocates of that hypothesis to consider.

I have mentioned the case of one of the meteors leaving a train visible during $2^m\ 40^s$. A much more striking instance occurred in the case of one which exploded close to the three bright stars in *Aries.* The train left at first was very bright, and very nearly parallel to the line joining α and β. It remained visible for no less than 6 minutes, during which time *it drifted slowly to the southwards over a space of* 8 *or* 9 *degrees, and at the same time gradually changed its direction, so that just before its disappearance it was at right angles to its original position.*

Collingwood, Nov. 15, 1866.

Inference from the observed Movement of the Meteors in the appearance of 1866, *November* 13–14. By G. B. Airy, Esq., Astronomer Royal.

It is established by abundant evidence that the meteors seen in the late magnificent display diverged, for the most part, with singular accuracy, from a point which may thus be described: join γ *Leonis* and ι *Leonis* by an arc of a circle, the Centre of Divergence was about a degree north of the middle of the arc. There were other centres of partial radiations, but this may be accepted as the centre of radiation of the general mass.

This was the case all through the night; in fact, the first exact determination of the point which reached me was from my son Mr. Hubert Airy, who had occasion to walk several miles between five and six o'clock in the morning of the 14th (Nov. 13, 17^h to 18^h), and carefully observed a considerable number of meteors, the intersection of whose paths he determined accurately; subsequently I received the chart of Mr. Alexander Herschel, made several hours earlier, and observations of other persons at different hours; and all agreed in fixing on the point which I have specified as the centre of divergence.

It will readily be understood that this divergence from one point is merely an effect of perspective; that the point of divergence is, in fact, the point opposite to what is usually known as the "vanishing point." It is, of course, theoretically possible to imagine an explosive point in space so changing its position as to produce effects like those which were seen; but no person, I suppose, will really maintain that explanation against the simple one, that the meteors, for the most part, retain a nearly unvaried relative position among themselves, and that the effects observed were produced by the relative movement of the Earth and the collection of meteors.

I assume here that the resistance of the air produced no remarkable change in the apparent paths of the meteors; which assumption appears to be justified by the agreement of the diverging points when far from the meridian and when near the meridian. The same agreement justifies us in thinking that the course of the meteors was not much disturbed by the Earth's attraction; a consideration, however, which in future must not be put out of sight.

I ought in strictness to have ascribed the observed effects to the relative movement of the *point of observation* and the collection of meteors; but this differs from the other by an extremely small quantity, and if the corresponding correction were applied, it would diminish the angle which I am about to mention by an insignificant fraction of a degree.

Now if the meteors had been stationary in space they would have appeared to diverge from that point in the celestial sphere towards which the Earth's motion was directed. That point is very nearly the point on the ecliptic 90° behind the Sun's apparent place, or is in longitude 141° nearly. The point of divergence did not very much differ, in longitude, from the point thus found; but it was north of the ecliptic by about 11°. It follows from this that the meteors were not stationary in space. They had not much motion towards or from the Sun; but they were moving perpendicularly to the plane of the ecliptic, from north to south, with an absolute velocity nearly $\frac{1}{5}$-part of the velocity relative to the Earth in the direction of the Earth's motion.

We have no information as to the real value of their velocity relative to the Earth in that direction, and every subsequent stage of investigation is therefore imperfect.

Let V be the velocity of the Earth in its orbit, and v the velocity of the meteors in the same direction (considered as perpendicular to the Earth's radius vector) the relative velocity of the meteors in that direction was $V - v$; we may neglect the absolute velocity towards the Sun; the absolute velocity perpendicular to the plane of the ecliptic was $\frac{V-v}{5}$; the total velocity of the meteors in space was

$$\sqrt{\left\{v^2+\left(\frac{V-v}{5}\right)^2\right\}}.$$

The smallest admissible value of v (in an algebraical sense) is that which makes the orbit round the Sun parabolic, supposing the meteors subject to the law of gravitation. This gives

$$v^2+\left(\frac{V-v}{5}\right)^2=2V^2,$$

of which the negative solution is $v = -V \times 1{\cdot}32$. From this, the absolute velocity perpendicular to the ecliptic

$$=\frac{V-v}{5}=V \times 0{\cdot}464;$$

and, as the meteors were then at the node, and the velocity v is perpendicular to the line of nodes, the tangent of the inclination of the orbit to the ecliptic is $=\frac{0{\cdot}464}{1{\cdot}32}=0{\cdot}35$ nearly, or the inclination is $= 19^\circ\frac{1}{4}$.

The largest admissible value of v is that beyond which the meteors would have been seen receding towards the vanishing point, or that which would have made them appear stationary. This gives $V-v=0$; motion towards the ecliptic $=0$; velocity parallel to the Earth's motion is $=V$; tan. inclination of orbit is $=\frac{0}{V}=0$.

We may therefore conclude that the inclination of the orbit of the meteors to the ecliptic is less than 19°.

If the absolute motion of the meteors in the direction of the Earth's movement on Nov. 13–14 was very small, the excentricity of their orbit would not be great; but in any other case it would be considerable.

Royal Observatory, Greenwich, 1866, *December* 10.

On the Meteor Shower of 1866, *November* 13–14. By Piazzi Smyth, Esq., Astronomer Royal for Scotland.

Agreeably with the important letter of Mr. A. S. Herschel, circulated by the President of the Royal Astronomical Society, meteoric shooting-stars were looked for here on the nights of the 12th and 13th instant.

On the 12th the sky was nearly covered with cloud; long,

hazy bands of which were radiating out of the E. N. East, and probably converging in the W. S. West,—but that quarter was usually too full of rain-squalls driven by the wind, itself nearly W. S. West, to allow of much being seen there.

Between the appointed hours of 1 and 2 A.M., only two shooting-stars were observed, both rising in their paths, and with a tendency from east to west, one of them below, and the other above, the stars of the *Great Bear*, which were only just visible through a space partially cleared of haze. The meteors appeared of about the brightness of stars of the first or second magnitude, had no visible trains, and the direction of their paths, produced backwards, converged on a centre not far above the eastern point of the horizon.

About 3^h A.M. another meteor was seen, of the same moderate brightness; but it was coursing along above the south and south-east horizon, and in a direction retrograde to the other two, or proceeding from west to east directly *to* the point which they had seemed to have emerged *from*.

The night of the 13th was very different, the sky being exquisitely clear, the stars everywhere very brilliant, and nothing extraneous to interfere with the astronomical features, except a little auroral light, low down on the N. N. West, and E. N. East horizons, and a few small patches of dark vapour in front of it.

Soon after 11^h P.M. shooting-stars began to be noticed as frequent; towards midnight, they were very noticeable; at $0^h\ 10_m$ A.M. an excessively brilliant one occurred, causing distinct shadows of dark objects to appear on the ground, and leaving a luminous track in the sky, near the three stars in the head of *Cepheus*, visible for nearly 12 minutes. The number of more ordinary shooting-stars was increasing all the time, and was probably at its maximum at $0^h\ 54^m$ A.M., when half-a-dozen were often visible together.

Upwards of 1000 had now been noted, though only in an irregular manner; but from $0^h\ 58^s$ to $1^h\ 58^m$ A.M. Greenwich Mean Time, they were observed more steadily by one observer looking towards the east, and an assistant noting the times, and with the result of 1492 being registered in the interval.

But this was by no means the whole number which the heavens displayed, for during the last half of this period a second observer watched towards the N. W. and registered rather more than half the numbers of the eastern observer. Although, too, some of them may be the same as his, others again, and even a large proportion, the N W. observer was certain, only began their visible flights somewhat west of the meridian. Hence, if we allow him only two-thirds his numbers, but imagine another observer stationed towards the S. W. and another again regarding only the zenith region of the sky, they would, amongst them, have had at least as many original meteors as the first observer looking east, so that his

numbers should be doubled, and 2984 be stated as the approximate number of meteors for that hour.

The numbers of these meteors, as taken minute by minute, were rather rough and conflicting; but on taking the sums of every successive *ten* minutes, an admirable regularity of continually decreasing numbers immediately showed itself, proving, without a single anomaly, that the meteors were decreasing through the hour; that the maximum had occurred before 1 o'clock A.M., and that in two hours, symmetrically arranged about the period of maximum, something over 6000 meteors must have occurred.

Or more accurately, by projecting the numbers observed, and drawing curves through them, the time of maximum may be regarded as $0^h\ 54^m$ A.M. and the total number of meteors over one hour, including that maximum

in its middle point, ...	4626
over two hours, similarly situated . . .	6426
four " "	7680
eight " "	8312

The observations were discontinued at $4^h\ 30^m$ A.M., when the number of meteors seemed to be only 3 against 89 at $0^h\ 56^m$ A.M.

The general characters of these meteors were, bright yellow balls, like *Jupiter* or *Venus* for brightness, but attended by long trains of faint and light-blue light; these trains usually lasted only from two to three seconds, were of an exaggerated long elliptical form, so as to be nearly invisible close to the bright head, and to be broadest near the middle of their length; and such broader central part of the train often remained abundantly visible long after the head, and chief part of the length of the train, had entirely disappeared; so decidedly too was this a material fact, and not any optical impression caused by the overpowering brightness of the head during the time it was visible, that often, on turning to a new part of the sky, the last expiring traces of such short central part of a meteor track were seen, proving that a meteor had just passed that way and been missed by the observer.

Some years since, an abundant display of meteors was compared to flakes of snow in a snow-storm; but that simile was by no means descriptive of the leading impressions of the scene on the 13th; for, excepting one small region of the sky presently to be noticed, there was a velocity, a certainty, and an almost apparent purpose in the motion of every meteor, quite apart from the uncertain characteristics of feathery snow. Without knowing anything at all of the actual distances of these bodies, they gave the impression of some ethereal description of rockets, but endued with the speed of cannon-balls, and half their purity of path; and one of them often followed

another, second after second, for several seconds together, as if discharged from the other side of the sky at something positive in the West, and with a determination to hit it too. One, and only one, case of directly retrograde motion was observed; a moderate number of crossing paths were noticed; but the immense majority of all cases, whether the motions were through the zenith, over the north or south horizons, was from East to West; and in a manner implying an original divergence from an eastward position, with an apparent separation overhead from perspective, and a convergence again towards the West.

The point of origin in the East was very visible among the stars of *Leo;* and not only were many of the larger trained and brighter meteors seen to emerge from that quarter, but many very short-trained, and apparently distant ones, were seen there, and there only. For a time indeed, about one o'clock, there seemed to be a glow of infinite numbers of distant, and not individually visible, meteors, in that direction, from its coinciding with the auroral light thereabout; but by two o'clock the constellation had risen above that accidental effect, and had carried the point of meteor origin so decidedly with it,—that whereas previously all the meteors were seen more or less rising upwards through the sky, though to different azimuths,—there were afterwards seen almost as many descending from that point to the horizon underneath it.

To test this important feature, a drawing was made of the sidereal sky as it appeared in the East at 2^h 5^m A.M., and from that moment to 2^h 15^m every meteor was marked on the paper, just as seen by the eye at the same instant among the stars in that quarter of the heavens, and the practical result is shown in the copy now transmitted.

Of particular meteors, it may be mentioned, that in addition to the instance alluded to above at 0^h 10^m A.M., there was another at 0^h 59^m 30^s, momentarily near the zenith, bright enough to illumine the interior of a dark room, and then descending apparently in two or three red pieces, nearly through the line of the tail of the *Great Bear;* and there must have been another about 2^h 40^m A.M. between α *Ursæ Majoris* and α *Ursæ Minoris*, for immediately thereafter the central part of its luminous track was brilliantly conspicuous, like a silver snake in the sky. From minute to minute the luminous line became more corrugated; widening and becoming fainter by degrees; and also drifting, apparently under the action of the N. W. wind blowing at the time; even after a quarter of an hour the train matter was still visible, but changed to something like the outline of a gigantic pear, and drifted some 30° from its first position.

Both this meteor and that of 0^h 10^m may be considered to have entered the Earth's atmosphere, and to have terminated their careers as planetary bodies revolving around the Sun

but these were in a proportion of less than 1 in 1000 of those which had every appearance of going past the Earth altogether, and having a chance therefore of being seen again on another Nodal passage.

The drawing, and the principal numerical particulars alluded to above, are appended to this Note, which I regret is not more worthy of the magnificent meteoric display of which it attempts to chronicle only some leading features.

Royal Observatory, Edinburgh,
14th November, 1866.

Number of Meteors seen by an Observer looking Eastward, and Registered by another:

During the Minute ending. h m	Number.	During the Ten Minutes ending: h m	Number.	During the Hour ending: h m	Number.
0 59 A.M.	28				
1 0	30				
1 1	32				
1 2	60				
1 3	60				
1 4	30				
1 5	36				
1 6	34				
1 7	64				
1 8	38	1 8 A.M.	412		
1 9	38				
1 10	29				
1 11	30				
1 12	40				
1 13	41				
1 14	40				
1 15	35				
1 16	35				
1 17	52				
1 18	50	1 18 A.M.	390		
1 19	44				
1 20	31				
1 21	30				
1 22	29				
1 23	29				
1 24	33				
1 25	30				
1 26	23				

During the Minute ending: h m	Number.	During the Ten Minutes ending: h m	Number.	During the Hour ending: h m	Number.
1 27	23				
1 28	23	1 28 A.M.	295		
1 29	20				
1 30	7				
1 31	6				
1 32*	20				
1 33	20				
1 34	20				
1 35	20				
1 36	20				
1 37	17				
1 38	18	1 38 A.M.	167		
1 39	16				
1 40	16				
1 41	16				
1 42	16				
1 43	12				
1 44	11				
1 45	11				
1 46	11				
1 47	11				
1 48	11	1 48 A.M.	131		
1 49	11				
1 50	11				
1 51	11				
1 52	10				
1 53	9				
1 54	9				
1 55	9				
1 56	9				
1 57	9				
1 58	9	1 58 A.M.	97	1 58 A.M.	1492

* From $1^h\ 32^m$ to $2^h\ 2^m$ A.M. the meteors were counted and the time entered only for every even hundred; and from thence have been arithmetically distributed through the included minutes.

Observations of the Meteoric Shower of 1866, *November* 13–14, *made at the Glasgow Observatory.* By Professor Grant.

The Meteoric Shower of November 13 was well seen here. Although the early part of the night was not favourable for observations, still a few shooting-stars were perceived as the sky from time to time became clear. These appearances occurred more frequently as the night advanced; but even about midnight the number of meteors seen was inconsiderable. Towards 13 hours G.M.T. the sky became clear in every direction, and fortunately continued so during the remainder of the night. Great numbers of beautiful meteors were now seen traversing every region of the heavens with a general movement directed from east to west. Multitudes of them were equal in brightness to stars of the first magnitude, many of them were equal to *Jupiter* when in opposition, while some of them even rivalled *Venus* when at her greatest brilliancy. Their prevailing colour was white, but some of them, especially the larger meteors, had an orange hue, while others again had a bluish tinge. They traversed the heavens with great apparent velocity. In many cases they described arcs of 50°, 60°, or 70°, although the interval of visibility did not in general exceed three seconds of time. In almost every instance the meteor, as it pursued its westward course, span out a beautiful train of light. The colour of this train was invariably a bright emerald green. In general the disappearance of the meteor preceded that of the train. While the meteor was visible, the train appeared to follow it straight as an arrow; but when the meteor vanished, by dissipating or bursting, the train was perceived to crumple up and rapidly melt away in the heavens. The observations were not long continued before it became evident that the meteors were directed from a definite region of the heavens situated in the constellation *Leo*, which was seen in the east, ascending above the horizon. This was indicated not only by the common direction of their westward motion, but also by the short dagger-like appearance of the trains which accompanied the meteors seen in the supposed region of emanation, contrasted with the almost invariably long trains of the meteors which passed the meridian during the short interval of visibility, a result obviously the effect of foreshortening.

At $13^h\ 15^m$ G.M.T. I endeavoured to count the number of meteors visible in a minute, and found it to amount to fifty-seven. At $13^h\ 20^m$ I counted forty-three in a minute. At $13^h\ 25^m$ I counted thirty in the same interval of time. At $13^h\ 30^m$ I counted forty-three in two minutes. At $14^h\ 4^m$ the number visible in a minute had diminished to thirteen.

At $14^h\ 41^m$ my attention was directed to an extraordinary blaze of light in the constellation *Ursa Major.* When first

seen it presented the appearance of a slightly curved broad band of light, indicative of the train of a meteor which itself had already disappeared, and which, judging from what was left behind, must have far exceeded in lustre any of the meteors seen during the night. The first apparition of this remarkable phenomenon I unfortunately lost, having been engaged at the time in writing down some details in my note-book. It was obvious, however, that the meteor had only just vanished, for the residuary mass of light was still very bright. I could only compare its appearance in this respect to that presented in a dark night by the blazing furnace of one of the great iron-works in the neighbourhood of Glasgow. In less than a minute after it was first seen, it assumed the appearance of a horse-shoe or inverted arch of diffused and rapidly diminishing light, one extremity of which was projected upon ι *Ursæ Majoris*, and the other upon γ and δ of the same constellation. Gradually it expanded in dimensions and grew fainter; at the same time the arch became more elongated and pointed, suggesting its resemblance to a merry-thought or the outline of a heart. At 14^h 48^m the western extremity was seen still to be attached to ι *Ursæ Majoris*, but the eastern had drifted from γ and δ to α and β of the same constellation, an effect doubtless attributable to the prevalence of a westerly wind which was blowing at the time. The apex was seen to descend as far as ψ *Ursæ Majoris*, or perhaps a little lower. This remarkable object continued to be distinctly visible till 14^h 56^m; even at 15^h traces of it might still be discerned.

At 15^h the number of meteors visible amounted to only two in a minute. At 16^h 30^m only one meteor was visible every two or three minutes. At 17^h the starry hemisphere was found to have resumed its normal aspect.

I subjoin a statement of the observations made on the occasion of the apparition of this magnificent phenomenon. My chief object was to obtain as many facts as possible for establishing the position of the Radiant Point. Fortunately the great numbers of meteors which continued to illuminate the heavens for several hours supplied an abundant field of materials for effecting that object by noting the courses of the meteors so chosen relatively to the stars over or near which they passed. The meteor paths thus observed were laid down upon one of the star-maps of the British Association, kindly furnished to me for the purpose by Mr. A. S. Herschel. They indicate the radiant point to be situated in

	° ′
R.A.	147 35
Decl. N.	22 53

This point is situated very nearly in the intersection of lines, one joining γ and ι *Leonis*, and the other η and μ of the same constellation.

I enclose also observations of the same phenomena made by Mr. John Plummer, one of the Assistants at the Observatory. These being similarly laid down upon one of the British Association star-maps, indicate the position of the radiant point to be—

	° ′
R. A.	150 30
Decl. N.	21 36

Mr. A. M'Gregor, the other Assistant at the Observatory, was placed under the direction of Mr. Herschel, who had selected the Observatory Hill as a convenient place for observing the phenomenon.

The Observatory,
Glasgow, Nov. 15, 1866.

Observations of the Meteors of November 13–14, 1866, *made at Glasgow Observatory by Mr. John Plummer, Assistant.*

Hour. h m s	Apparent Size.	Position.	Appearance, Train, if any, &c.	Length of Path.	Direction.
13 34 33	1st mag.	From a point 3° north of δ Orionis towards S.W. point of horizon	Bright streak		
13 36 34	2nd mag.	From a point 4° east of Mars towards S.S.W.	Short streak		
3 38 28	= Sirius	From a point 12° S.S.E. of α Orionis to 2° south of Rigel	Streak		
13 39 29	2nd mag.	From Aldebaran to *f* Tauri			
13 42 45	2nd mag.	From a point 4° south of η Tauri	...		Due west.
13 44 53	1st mag.	From ½ κ Orionis-Sirius towards S.W. point			
13 46 25	...	From β Can. Min. towards Rigel			
13 47 35	> Sirius	Seen through cloud in due west about 50° of altitude at commencement	...		Perpendicular.
13 53 5	= Sirius	From a point 3° north of Procyon towards θ Orionis	Fine streak, lasting 4 sec.		
13 54 56	1st mag.	From a point 3° south of Pollux towards Aldebaran			
13 56 58	...	From ½ Procyon-Rigel towards Rigel			
14 8 17	2nd mag.	From a point 3° south of κ Orionis towards S.W.	...	40°	

Hour.	Apparent Size.	Position.	Appearance, Train, if any, &c.	Length of Path.	Direction
h m s					
14 9 52	1st mag.	From a point 7° south of Aldebaran towards west point			
14 11 39	2nd mag.	From a point 6° south of Aldebaran towards west point			
14 13 57	2nd mag.	From a point 3° east of α Ceti towards W.N.W.			
14 16 59	2nd mag.	From a point 5° south of Rigel towards S.W. point			
14 18 58	...	From a point 10° east of Capella to that star			
14 21 0	2nd mag.	From ½ η Tauri-Aldebaran towards west point			
14 23 21	1st mag.	From a point 1° north of Procyon towards Rigel	Streak		
14 28 36	1st mag.	From a point 5° east of γ Orionis to west point	Streak		
14 29 39	1st mag.	From Aldebaran towards W.S.W.	Fine streak. Disappeared in the middle of its course	55°	
15 2 20	1st mag.	From a point 3° north of Procyon towards θ Orionis			
15 9 15	1st mag.	From a point 6° east of Procyon towards α Orionis			
15 42 47	1st mag.	From a point 2° north of β Can. Min. towards η Orionis			
15 46 15	Flashed = Sirius	From a point 6° below Regulus	...	7°	Course perpendicular.
15 55 5	1st mag.	From a point 8° north of η Tauri	...	10°	Course perpendicular.

Time of Obs. 1866, Nov. 13.	Apparent Size.	Position.	Appearance, &c.	Duration.
h m				
13 21	1st mag.	From Mars to α Tauri		
13 22	1st mag.	γ Leonis to α Tauri	White	3 sec.
13 28	1st mag.	β Can. Min to β Orionis	White	3 sec.
13 32	2nd mag.	From Pollux to centre of Pleiades	White	

Time of Obs. 1866, Nov. 13.	Apparent Size.	Position.	Appearance, &c.	Duration.
h m				
13 34	1st mag.	From α Orionis to γ Orionis	White	
13 36	1st mag.	Mars to γ Orionis	White	3 sec.
13 37	= Jupiter	Capella to β Persei	White	4 sec.
13 38	= Sirius	Regulus to ζ Urs. Maj.	Orange-yellow	
13 39	= Jupiter	β Aurigæ to Capella	Yellow	4 sec.
13 40	1st mag.	ζ Leonis to η Urs. Maj.	White	2 sec.
13 41	2nd mag.	γ Leonis to ζ Leonis	White	
13 42	1st mag.	Procyon to α Orionis	White	
13 44	1st mag.	Procyon to α Orionis	White	
13 48	1st mag.	Procyon to α Orionis	Yellow	
13 49	1st mag.	β Can. Min. to θ Orionis		
13 51	1st mag.	γ Leonis to α Cassiop.	White	4 sec.
13 55	1st mag.	γ Leonis to γ Urs. Maj.		3 sec.
13 56	1st mag.	η Leonis to Regulus	White	2 sec.
14 1	1st mag.	β Tauri to a point 1° south of Pleiades	White	3 sec.
14 6	2nd mag.	Procyon to β Orionis	White	
14 8	2nd mag.	γ Leonis to δ Leonis	White	
14 10	2nd mag.	γ Leonis to centre of Presepe	White	3 sec.
14 11	1st mag.	ι Leonis to η Leonis		
14 12	1st mag.	Procyon to β Orionis	White	
14 16	1st mag.	γ Leonis to δ Leonis	White	
14 18	= Sirius	Pollux to 1° north of α Tauri	White	3 sec.
14 21	1st mag.	Procyon to α Orionis	White	3 sec.
14 23	1st mag.	α Leonis to γ Leonis	White	2 sec.
14 24	1st mag.	Mars to Aldebaran	White	3 sec.
14 25	1st mag.	a point 2° north of Procyon to β Orionis	White	
14 28	1st mag.	a point 2° north of Procyon to β Orionis	White	3 sec.
14 31	1st mag.	a point 1° north of Mars to β Tauri	White	2 sec.
14 32	1st mag.	γ Leonis to a point 4° north of β Leonis	White	
14 36	1st mag.	Procyon to a point 4° south of β Orionis	White	
14 37	2nd mag.	From δ Urs. Maj. to γ Urs. Maj.	White	

Time of Obs. 1866, Nov. 13. h m	Apparent Size.	Position.	Appearance, &c.	Duration.
14 38	1st mag.	From ζ Leonis to η Urs. Maj.	White	
14 40	1st mag.	Aldebaran to a point 2° north of α Leonis	White	
14 55	1st mag.	α Arietis to β Tauri	White	
14 57	1st mag.	θ Leonis to β Leonis	White	
15 2	= Jupiter	From a point 2° north of Procyon to β Orionis	White	4 sec.
15 28	1st mag.	Through a line bisecting at right-angles the line joining η Leonis and ι Leonis	White	
15 30	1st mag.	From ι Leonis to ρ Leonis	White	
15 46	1st mag.	From a point 1° north of Procyon to θ Orionis	White	

Meteors observed at Cranford, November 13th–14th, 1866. By Warren De La Rue, Esq.

The night of the 12th–13th November was cloudy, and no observations were made. That of the 13th–14th was very brilliant during the early part of the night, and although occasionally the sky was partially obscured by thin clouds, and that a slight mist prevailed over the heavens from one o'clock to half-past three on the morning of the 14th, no interruption of the observations occurred from that cause. The wind was very high and piercingly cold,—so cold, indeed, that, although I and my two assistants were well clad, it required all our enthusiasm to prevent our discontinuing the observations. The noise produced by the rustling of the surrounding trees quite prevented any detonation from being audible, supposing such to have occurred which produced a report which would have reached the ear on a calm night. My two assistants were Mr. Reynolds and my nephew Mr. Percival James. Our place of observation was in a large archery ground, with an open horizon scarcely obstructed by surrounding objects in those directions most favourable for observations. I have often witnessed fine displays of meteors, and have seen many much more brilliant than any visible on this occasion; but I never before saw anything approaching to the grandeur of the scene presented on this occasion, especially between 1 o'clock and $1^h\ 20^m$ on the morning of the 14th. A few meteors were seen before 11 o'clock, and at $11^h\ 45^m$ the display had fairly

commenced, and gradually increased in brilliancy until about 20 minutes past 1 o'clock; after which the number of meteors gradually diminished, and at $1^h\ 43^m$ I made a note that the number was sensibly less.

With three exceptions all the meteors appeared either to emanate from the constellation *Leo*, and to shoot from this part across the heavens in divergent curves, resembling, on account of perspective, the segments of an orange, or else to converge in downward curves towards a point nearly diametrically opposite to that constellation. Facing *Leo* one could not fail to be impressed with the conviction that within that constellation was situated the radiant point; some of the meteors became visible in that group of stars as small specks of light, which rapidly increased in brilliancy and then suddenly faded out, leaving in some cases a visible vapour which lasted for several seconds. The meteors shot out from this constellation, upwards, downwards, and to the right and the left, but all evidently from one radiant centre, with the exception of the three before named, whose paths were irreconcilable with the supposition of their being connected with the system to which the grand display belonged. *Orion* and the *Great Bear* were specially favoured with brilliant shooting stars, and one which shot across *Orion* left a trail which was visible for three minutes. Many of the trails were watched through a binocular opera-glass, and were observed to curl up and gather in curvilinear knots at right angles to their path, and very gradually to fade out. One such was observed about 12^h for 2 minutes 13 seconds, and seemed to gather itself into an irregular spiral, as if acted upon by conflicting currents. The position of this trail was below the constellation *Andromeda*. Several nebulous masses of vapour were picked up through the opera-glass in the neighbourhood of the tracks of previous meteor-flights, and watched for several minutes before they disappeared completely. About one o'clock the flight of meteors apparently shooting downwards from the zenith, and from points to the north and south of the zenith through *Andromeda*, *Lacerta*, *Pegasus*, and *Cygnus*, towards the horizon diametrically opposite to *Leo*, was so continuous and brilliant, that it recalled to mind the final display of fireworks known as the *bouquet*, with this difference, that the rocket-like streams shot downwards instead of upwards. About the same period the bursts of globes of light in *Leo*, and the rocket-like meteors shooting from it, were most strikingly beautiful. I, however, consider the most brilliant display was the downward rush towards the western horizon. Many attempts were made to get the binocular opera-glass on to a meteor, but I was not quick enough to do so, although I was watching in the direction to which many came. I began at $11^h\ 45^m$ on the night of the 13th to note down the principal meteors; but as the exclamations of my assistants kept me

informed of many brilliant meteors having escaped my observation, I gave up the attempt for a time at about half-past 12 o'clock.

The following observations were made of some of the principal meteors:—

No.	h m s	
1	11 45 11	A brilliant meteor from the Great Bear towards Cassiopeia, visible through a path of 35° to 40°, shining with a blue light, and leaving a trail which marked its path for several seconds.
2	11 46 0	From eastern horizon towards the Great Bear.
3	11 47 56	A bright meteor whose path could be traced for 30° from east into the constellation of the Great Bear.
4	11 48 34	A splendid meteor springing from Orion's belt towards the south in a nearly horizontal direction; path visible for 20° to 30°, shining with a blue light, and occupying about 2ˢ in its flight.
5	11 49 49	A meteor from Leo, and passing into the Great Bear between α and β about midway.
6	11 50 21	A meteor in direction parallel to β and α of the Great Bear.
7	11 51 32	From Polaris southwards.
8	11 52 0	Towards Great Bear.
9	11 53 29	Two meteors in parallel paths below κ and β Orionis southwards.
10	11 54 45	From the east towards the tail of the Great Bear, disappearing just below ι.
11	11 56 30	From the north in a direction parallel to Mizar and η in the tail of the Great Bear.
12	11 57 8	A splendid meteor started from about 20° above the horizon, passing almost in a vertical direction to the right of β and α Ursæ Majoris. Duration of flight 2ˢ.
13	11 58 15	Another splendid meteor vertically upwards to the left of Mars, shooting past Capella.
14	11 59 7	A meteor starting from β Orionis towards the south, leaving a trail 15° in length.
15	12 0 15	Two very bright meteors about 3° apart, passing one on one side, the other on the other of Capella towards the Pleiades.
16	12 1 0	A meteor across the Pleiades.
17	12 1 10	A meteor from east passing midway between β, γ, and α, δ of the Great Bear.
18	12 2 48	A meteor followed by a second, shooting upwards on the left, and close to Mars.

No.	h	m	s	
19	12	3	35	From left in a nearly horizontal direction under α Canis Minoris.
20	12	4	8	A bright meteor starting from a point just under β Geminorum, becoming faint, then bursting out with greater brilliancy as it neared α Tauri.
21	12	5	18	A brilliant meteor whose path was about 25° from the east in a nearly horizontal direction, and passing over α Ursæ Majoris.
22	12	6	26	A still more beautiful meteor from α Canis Majoris.
23	12	8	0	A splendid meteor shining with a brilliant blue light, and visible for 30°, shot from a point just under the nose of the Bull, in a direction diagonally downwards.
				Between this and the following two other bright meteors caught the sight nearly below the path of No. 23, just recorded.
24	12	10	11	A splendid meteor shot towards the right just above β Orionis.
25	12	11	9	A meteor shot across from east, about 3° below Mars and disappeared just under γ Geminorum.
26	12	11	47	Past Castor southwards.
				Four whose positions were not noted between the above and next observation.
27	12	19	59	Over α and γ Orionis.
				Five in rapid succession between the above and next positions not noted.
28	12	13	33	A meteor with a brilliant head; the head orange in colour, and leaving a trail shining with a blue light, shot in a direction parallel with horizons starting just under Mars, and passed southwards.
29	12	14	44	A brilliant meteor started about 5° below Mars, and disappeared close to α Canis Minoris.
30	12	15	24	A double meteor passed over α Canis Minoris.
31	12	15	59	In a horizontal direction passing over α Canis Minoris.
32	12	16	39	A point of light expanding into a large ball as bright as Venus at her brightest, and then disappearing near η Leonis.
33	12	19	0	A bright meteor, whose path extended about 15°, passed from the east between β, α, and γ, δ Ursæ Majoris.
34	12	19	37	A very bright meteor, which disappeared just above α Ursæ Majoris.
35	12	20	14	A meteor in a direction parallel with λ and δ Ursæ Majoris, disappearing about 1° beyond the latter star.
36	12	20	24	A meteor from east, over the constellation of the Great Bear.

No.	h m s	
37	12 21 4	A bright meteor, visible for 15°, passed under the belt of Orion, which was about the centre of its flight.
38	12 21 39	A splendid meteor, followed almost immediately by another nearly as bright, shot diagonally downwards, just below κ Orionis, which was about in the centre of its track.
39	12 22 4	Two meteors in parallel paths across the constellation Auriga.
40	12 22 9	A brilliant meteor, starting vertically upwards from Leo.
41	12 23 14	Two meteors shot pass η Leonis.
42	12 24 19	A very bright meteor in a direction parallel with γ and δ Ursæ Majoris between these stars and ϵ.
43	12 25 4	A brilliant meteor just over ϵ Tauri, in a direction nearly parallel with the horizon.
44	12 30 2	A splendid meteor from east, and passing between β, α, and γ, δ of the Great Bear.
45	12 31 49	A very bright meteor, whose path was visible for 30°, passed over the belt of Orion, and left a trail which was visible for fully three minutes.
46	12 32 37	A very bright meteor near to the horizon, a little to the right of Leo.
	At 1 43 0	The number of meteors had sensibly diminished.
47	2 15 27	A brilliant meteor burst just over 42 Leonis, the trail from foreshortening appearing only 1° in length.
48	2 41 0	A magnificant meteor burst over ϵ Lyræ, 2° to the east and 1½° below that star.
49	2 42 13	A brilliant meteor passed between ζ and η in the tail of the Great Bear, and disappeared just over the latter star.
50	3 4 45	A splendid meteor disappeared just over Mars.
51	3 5 58	Bright meteor just under and 2° to the right of 9 Bootis.

The prevalent colour of the meteors was blue; in a few cases an orange head, leaving a greenish trail, was observed, and in some cases the light of the head was green.

h m					
12 34	Mr. Reynolds observed		13 meteors in a minute.		
12 36	,,	,,	21	,,	,,
12 37	,,	,,	12	,,	,,
12 38	,,	,,	14	,,	,,
12 39	,,	,,	17	,,	,,
12 40	,,	,,	15	,,	,,
12 41	,,	,,	4	,,	,,

h m					
12 42	Mr. Reynolds	observed	16	meteors	in a minute.
12 43	,,	,,	28	,,	,,
12 44	,,	,,	27	,,	,,
12 45	,,	,,	21	,,	,,
12 46	,,	,,	25	,,	,,
12 47	,,	,,	24	,,	,,
12 49	,,	,,	31	,,	,,
12 52	,,	,,	17	,,	,,
12 53	,,	,,	20	,,	,,
12 54	,,	,,	22	,,	,,
12 55	,,	,,	20	,,	,,
12 56	,,	,,	20	,,	,,
12 59	,,	,,	34	,,	,,

Between 1 o'clock and 1.20 I noted 33, 37, 33 meteors per minute.

Mr. Reynolds at the same time, looking in an opposite direction, noted 31, 29, and 30 in the same minute, consequently about 64 meteors were noted by two observers in the same minute. I was looking towards *Leo;* Mr. Reynolds to the point diametrically opposite.

h m s	
At 1 50 0	I and Mr. Reynolds only observed together 25 meteors in the minute.
At 2 25 0	One observer looking towards Leo and the other in a direction diametrically opposite, observed together only 3 meteors in a minute.
At 2 27 0	There were observed 14 in a minute.
3 9 0	Two observers, placed as before, observed 11 meteors in the minute.

Observations of the Meteoric Shower of November 13–14, 1866, *made at the Radcliffe Observatory, Oxford.* Communicated by the Rev. R. Main.

Owing to the uncertainty of the exact time of the expected meteoric display, a strict watch was kept up during the night of Monday, Nov. 12, as well as during the whole of the following night of Nov. 13, when it actually occurred.

Up to the very time when the meteors began to appear with frequency, that is, till about 11 o'clock, the appearance of the sky was unfavourable. The afternoon was clear, but shortly before 11^h, clouds suddenly made their appearance, and it began to rain. The clouds, however, quickly disappeared, and, though they interfered occasionally with the observations, they did not prevent materially the observing of the phenomena.

Mr. Lucas began to observe a few minutes after 11^h, and

was joined by Mr. Quirling at midnight, and for about half an hour after this it was possible to make notes of the locality and appearance of the meteors, but afterwards the numbers increased so rapidly that it was impossible to do scarcely any thing more than count them.

The following is an abstract of the observations of individual meteors:—

Approx. Greenwich M.T. h m s	Constellation or Place of Appearance.	Direction.	Magnitude as compared with Stars.	Colour, &c.	Notes.
11 9	Gemini	E. to S. upwards about 45°	2	Red	
15	,,	E. to S.	2	White	
25	,,	E. to S.	1	Red	A long train; disapp. hidden by the tower.
28	,,	W.		Red	A long train.
29	,,	E. to S.	1	White	A long train.
30	Eridanus	E. to S.	1	White	Motion downwards.
32	Ursa Major	E. to S.	3	White	Motion upwards.
35	Gemini	W.	2	White	
38	Ursa Minor	W.	2	Red	
40	,,	W.	3		
44	Ursa Major	W.	3	..	To this time the observations were made on the grounds at the south front of the observatory. After this Mr. Lucas removed with the chronometer to the terrace outside the octagon room.
55	,,	Vertically	3		
56	Lynx	S	2	Red	
58	Gemini	S.	2	Red	
59	,,	S.	1	Red	Two very near each other seen at an interval of one second; they moved in parallel paths over Orion.
12 2 50	Ursa Major	W.	2	Red	
2 50	,,	W.	2	Red	
3 40	Draco	W.	3		
4 10	,,		2	Red	
5 20	,,		2	Red	
6 30	Cancer	S.	1	Red	Up to this time Mr. Lucas had counted 14 small meteors which he had not time to register.
6 30	,,		1		
7 30	Leo	S.	1		
7 55	Ursa Minor	W.			
7 55	,,		2		
8 50	Ursa Major	W.	3		
9 25	Orion	W.	1		Motion downwards.
9 45	Ursa Major	W.	2		
10 30	Draco	W.	2		
10 30	,,	W.	2		
10 40	,,	W.			
10 40	,,	W.			
11 47	Leo	W.			
12 5	Ursa Major	W.			A train.

Approx. Greenwich M.T. h m s	Constellation or Place of Appearance.	Direction.	Magnitude as compared with Stars.	Colour. &c.	Notes.
12 12	Ursa Major	W.			
12	,,	..	3		
14	Leo	..	3		
14	,,	..	2		
15	Canis Minor	..	2		
15	,,	..	2		
15	,,	..	2		
17	Ursa Major	..	3		A train.
17	Ursa Minor	..	1		
18	Zenith	..			A train.
18	Caris Minor	..			A train.
19	Ursa Major	..			A train.
19	,,	..	1		A train.
19	,,	..	1		A train.
20	Cancer	..	1		
20	Orion	..			
20	Zenith	..			
20 30	,,	..	2		
21 0	Ursa Major	..			
21 0	,,	..			
21 50	Zenith	..			
21 50	Orion	..			
22 10	Gemini	..			
22 10	,,	..			
22 40	Cancer	..	1	Red	
23 0	Ursa Major	..			
23 15	Orion	..			
23 30	Zenith	..			
23 40	Cancer	..	1		
23 40	,,	..	2		
23 40	,,	..			
23 40	,,	..			
24 40	Draco	..	1		
24 40	,,	..			
25 0	,,	..	2		
26 10	Ursa Minor	..	2	Red	
26 40	Gemini	..	1		
26 40	Ursa Major	..			
27 0	,,	..	2		
27 0	,,	..			
27 40	,,	..		..	To this time 22 more smaller meteors had been counted.
28 40	,,	..	1		

Approx. Greenwich M.T.	Constellation or Place of Appearance.	Direction.	Magnitude as compared with Star.	Colour. &c.	Notes.
h m s					
12 28 40	Orion	..	2		
28 40	Boötes	..	2		
29 10	,,	..			
30 30	Zenith	..			
30 30	Zenith				
31	Leo Minor	..		..	To this time additional n been counte 27m 0s and 3
31	,,	..	1		
31	,,	..	1		
31	,,	..	1		
31	,,	..	1		
31	,,	..	1		
31	Zenith	..			
31	,,	..			

After this time the numbers increased so rapidly, was necessary to suspend all specific observation o excepting the counting.

The following table gives an abstract of the numbe

Approx. Greenwich M.T.	Numbers counted in the Interval.	Notes.
h m s		
12 31 0		
31 40	4	
31 50	1	In Orion.
31 50	1	In Ursa Major.
32 50	3	In the north.
33 20	4	,,
34 10	6	
35 0	4	
35 30	3	
35 50	4	At this time lightning from a darl cloud on north horizon.
36 50	3	
37 30	4	
38 10		12 smaller counted.
38 30	2	In the zenith.
38 40	11	
39 40	11	
40 40	5	
41 10	6	
41 40	8	
42 10	12	
42 20	8	

Approx. Greenwich M.T. h m s	Numbers counted in the interval.	Notes.
43 40	11	
44 40	14	
45 40	15	
46 40	24	
47 40	22	
48 40	19	
49 40	38	
50 40	18	
51 40	20	
52 40	30	
53 40	50	
54 40	30	
55 40	22	
56 40	28	
57 40	22	
58 40	30	
59 40	34	
13 0 10	40	
0 40	30	
1 40	60	
2 40	65	
3 40	80	
4 40	95	
5 40	82	
7 40	106	At the rate of 53 per minute.
9 40	155	,, 78 ,,
10 40	123	,, 123 ,,
12 10	107	,, 71 ,,
15 40	148	Clouds.
19 40	190	
23 40	235	A large meteor with comet-like appearance in Orion at this time.
28 40	168	
31 40	65	Interrupted by clouds for 20^m.
51 10	1	In the zenith; very red.
53 40	66	
56 10	21	
14 0 0	42	
2 40	28	
6 30	28	
8 10	22	
9 10	1	With a long white train.
12 40	42	

Approx. Greenwich M.T. h m s	Numbers counted in the interval.	Notes.
14 15 10	20	
16 0	1	Burst in the east.
19 10	19	
24 10	28	
28 10	16	
31 10	13	
35 10	16	
38 40	8	
39 40	2	
40 10	2	In the west. While recording this number, th room was illuminated by the bursting of large white meteor near Lyra (S.P.), of whicl Mr. Lucas caught a glimpse through th window.
45 10	19	
50 0	19	
53 50	11	
58 10	17	Wind rising.
15 3 40	17	At this time Mr. Lucas went to the West Ter race, and in the interval before the next re corded time counted the numbers given, 1 in the east and 13 in the west.
10 10	23	
13 40	11	
20 40	11	5 in the east, and 6 in the west.
26 40	12	One of them very bright.
32 0	11	
39 0	11	
43 40	7	
15 46 20	7	
15 46 20	1	White; in Lyra.
48 40	1	White; in Auriga.
55 20	10	
57 40	4	
16 0 50	5	The wind has increased to the strength of 4.
6 0	6	
9 40	2	From Aldebaran.
9 40	3	In the eastern half of the sky.
13 40	3	One in the east and two in the west.
17 10	6	Two east, and four west.
21 0	10	Four east, and six west.
24 40	1	East.
27 40	5	Three east, and two west.
32 20	1	East.
		The observers (Mr. Quirling and Mr. Lucas) to a rest of nearly 40 minutes.
17 10 0		Zodiacal light visible.
13 40	7	
16 40	5	

Approx. Greenwich M.T. h m s	Numbers counted in the interval.	Notes.
17 18 30	1	1st mag.; white, from Draco eastward.
22 40	1	1st mag.; blue; from Leo eastward.
22 40	4	
28 0	2	
28 55	1	1st mag.; white; from Draco westward.
35 0	3	
36 0	1	1st mag.; reddish; from Urs. Maj. northward.
40 10	5	
44 0	1	1st mag.; reddish; from Leo vertical.
48 0	2	1st mag; from Leo.
51 10	4	Through Leo and Gemini.
56 0	3	Through Leo and Boötes.
18 0 0	1	1st mag.; in Boötes.

The chronometer was compared with the transit-clock, and it was found to be 20^s fast on Greenwich mean time. The observed times have all been corrected for this error.

In general Mr. Lucas kept the record of the observations, but, during the time of the greatest numbers, the observers (Mr. Quirling and Mr. Lucas) each counted in his own division of the heavens, Mr. Quirling watching the portion south of the prime vertical, and Mr. Lucas the portion north of the prime vertical.

The whole number of meteors counted throughout the night, was 3087, of which about 2000 fell between 13^h and 14^h. Those which left trains were the brightest, the train remaining visible only for a few seconds in general.

In one particular instance, however, (that at $13^h\ 23^m\ 40^s$) the train was visible for some minutes. This meteor, which appeared in the belt of *Orion*, was very bright, and left its train apparently attached to ζ *Orionis*, giving to that star the appearance of a comet with a tail of nearly 3° in length, standing out at a position angle of 45°; it then detached itself from the star, keeping up the same route as the meteor, but forming itself into a ball of faint cometic appearance of about $15'$ in diameter, which grew dimmer and more diffused, and disappeared altogether after a lapse of 4 or 5 minutes, at a distance of nearly 1° from ζ *Orionis*, and at a position angle of about 110°.

In several instances the meteors disappeared for an instant as if hidden by the clouds, and then reappeared, following their former course (generally downwards). This was observed only by Mr. Lucas who was watching towards the North East. The greatest attention was directed towards the eastern

portion of the sky, as it was from this quarter that the display was expected.

It may also be mentioned that as both observers were on the Eastern terrace, a considerable portion of the western sky was hid from their view.

On the Meteoric Shower of 1866, *November* 13–14. By the Rev. W. R. Dawes.

The glorious display of the November meteors was seen to great advantage from this station during the night of the 13th, the sky, after a rainy day, having almost entirely cleared by about 8^h. A few meteors were seen in the evening; but no regular watch was commenced till about 11^h. I had two assistants; and, as feeble health forbade my being exposed to the keen W. by N. wind (which formed the only drawback to the pleasure of the exhibition), I took my station with one assistant on the east side of my house, having a good view of nearly the whole of the eastern hemisphere. My other assistant, who was also unable to face the cold blast, I stationed at an upper west window of the house. The only clouds were a few near the northern horizon, and a bank along the western horizon scarcely higher than from 5° to 7°.

At first I intended to note the G.M.T. of the appearance of the most remarkable meteors, and the course each pursued among the stars, with their relative brightness, colour, &c.; and for some time I accomplished this, and will here state the particulars of some of the brightest.

G.M.T. h m s	Remarks.
11 22 0 ±	A little south of *Rigel*: course due west: long bright train: extinguished at an altitude of 35°: pinkish: brighter than *Mars* or *Sirius*: nearly as bright as *Venus* at her maximum.
11 26 0 ±	From *Pollux*, through *Aldebaran*, and about 20° beyond; decidedly of a greenish hue.
11 45 10	From *Mars* over the zenith: as bright as *Venus* at maximum; leaving a long and bright train.
11 47 0 ±	Very bright: through α *Andromedæ*.
	Up to midnight 75 meteors were counted in the eastern hemisphere.
12 6 30	From a little south of *Procyon* to 15° above *Sirius*. As bright as *Venus* at maximum.
12 21 15	Through α *Orionis*: as bright as *Jupiter*.
12 22 40	Shot a little north of *Mars*: brighter than *Mars*.
12 32 0 ±	Bright: from β *Canis Min.*: through the [illegible] of *Orion*.

At this time the meteors became so numerous that while noting down the particulars of one I lost sight of ten or more. I therefore gave it up, and determined to note the instant when each succeeding hundred were counted in the eastern hemisphere, and will here set down the numbers counted after midnight.

G.M.T. h m s	No.	G.M.T. h m s	No.	G.M.T. h m s	No.
12 18 28	100	13 3 47	1100	13 22 40	2000
12 30 0	200	13 5 43	1200	13 25 33	2100
12 36 30	300	13 7 33	1300	13 28 50	2200
12 42 25	400	13 9 33	1400	13 33 0±	2300
12 47 15	500	13 11 30	1500	13 38 10	2400
12 50 28	600	13 13 20	1600	13 43 37	2500
12 54 0	700	13 15 35	1700	13 50 50	2600
12 56 55	800	13 18 3	1800	14 0 15	2700
12 59 50	900	13 20 0±	1900	14 13 10	2800
13 1 4	1000				

At $14^h\ 3^m\ 35^s$, a rather bright one passed exactly through *Castor*.

Towards the west nearly 400 were counted before $13^h\ 15^m$; about which time they became so numerous (6 or 8 being visible almost simultaneously), that my assistant stationed there became bewildered and "lost count;" not having been provided with the means of noting down the number. It appears, therefore, that about 3300 were *counted*, and from what I saw during an occasional peep into the western hemisphere, I conclude that more than 3500 were seen; beside many which must have escaped observation.

I attempted to trace backward several of the most remarkable meteors to the radiant point; and concluded that it lay decidedly to the N.W. of γ *Leonis*. It was certainly not identical with that star, but seemed to lie in a line from *Regulus* towards μ *Leonis*, and about twice as far from *Regulus* as from μ. More exactly than this I failed to determine it.

Two remarkable individuals were observed, which may be worthy of special notice, though at the time the numbers were so great that the time of appearance was not noted. This I regret, as it would have been interesting to ascertain whether the same were noticed elsewhere. About $13^h\ 30^m$ a pretty large meteor, about the size of *Mars*, passed from near *Procyon* a little above α and γ *Orionis*. Its motion was much slower than that of most others; it was perfectly round, and its colour was that of rather dull red-hot iron. It looked like a large red-hot shot at a great distance. Its brightness gradually faded after it had passed *Orion*, and it quite disappeared at about 25° west of γ *Orionis*, but without any appearance

of combustion: and it left no train behind. I called the attention of my assistant to it, who saw it exactly as I did.

The other was very bright, arriving at its maximum at about 45° from the zenith towards the west, where it seemed to be suddenly extinguished, leaving a long and brilliant train. But in a second or two afterwards it again lighted up, though with an inferior degree of brightness, and passed on rapidly behind the bank of clouds near the western horizon.

Several near the radiant point in *Leo* appeared like a little puff of steam, and assumed a form like a shuttle, which forcibly reminded me of the great nebula in *Andromeda*, as seen with small optical power. These usually remained nearly stationary, though some seemed to twirl round through 20° or 30° while disappearing.

The peculiar meteor described by the Rev. R. Main in a notice in *The Times* as seeming to cling to ζ *Orionis*, and then pass on westward, was seen here almost exactly as he described it. It remained so long visible, and looked so much like a nebula or faint comet, that but for its gradual loss of light it might have been easily mistaken for such an object.

Several faint flashes of light were seen; and I doubted at the time whether they were really very faint sheet lightning, or the reflection of remarkably bright meteors which were out of sight.

Only two or three were observed to take a course contrary to the rest. One of these, very bright, darted down behind the eastern horizon.

Grand as was the display, there was not a single meteor which would bear comparison with several which I saw at Ormskirk on the 13th of November, 1832; on which occasion, notwithstanding a pretty bright moon, three or four cast a very dark shadow of my Observatory towards the side on which the moon was shining. A very thick fog suddenly arose at about 15h; but several of the country folk going early with agricultural produce to Liverpool said that "though there was a terribly thick fog, yet *it lightened all the way*." So that probably many brilliant specimens darted across till near sunrise. Of that splendid display I have never met with a good and particular description. It was the first I had witnessed, and I have never since seen anything like it with respect to the brilliancy of many of the meteors, which, though not quite so large, yet gave as much light as the full moon.

Hopefield Observatory, Haddenham, Bucks.
1866, Dec. [illegible]

The Meteoric Shower of November 13–14, *as witnessed at Mr. Bishop's Observatory, Twickenham.* Note by J. R. Hind, Esq.

The points to which attention was chiefly directed here were the position of the Radiant and the enumeration of the meteors, with a view to fix the precise time of the maximum. Our party consisted of four observers—M. Du Chaillu, Mr. Hampshire, Mr. Wiss, and myself. With regard to number, the following figures exhibit some of the results obtained:—

	h m s		h m s			
From	12 0 0	to	12 22 0	101	meteors were	counted.
	12 22 0	,,	12 30 0	102	,,	,,
	12 30 0	,,	12 35 0	100	,,	,,
	12 35 0	,,	12 39 10	100	,,	,,
	12 39 10	,,	12 42 0	100	,,	,,
	12 42 0	,,	12 45 40	100	,,	,,
	12 45 40	,,	12 48 25	100	,,	,,
	12 48 25	,,	12 51 50	100	,,	,,
	12 51 50	,,	12 54 35	100	,,	,,
	12 54 35	,,	12 57 30	100	,,	,,
	12 57 30	,,	12 59 38	100	,,	,,
	12 59 38	,,	13 0 0	17	,,	,,

Making a total between $12^h\ 0^m$ and $13^h\ 0^m$ (Greenwich time) of 1120 meteors.

From $13^h\ 0^m$ to $13^h\ 7^m\ 5^s$ 514 were counted, and at the latter moment a somewhat sudden increase in the number occurred to such an extent that it became almost impossible to estimate the meteors in successive minutes, nevertheless $13^h\ 11^m$ was indicated as the time of maximum, and I think without a probable error exceeding $1\frac{1}{2}$ or 2 minutes at the most. From $13^h\ 52^m$ to $14^h\ 8^m\ 55^s$ we counted 300, but remarked that they were generally less conspicuous for brightness and length of train than about the maximum. From $15^h\ 9^m$ to $15^h\ 23^m\ 55^s$, 100, mostly faint, were noted. From $16^h\ 42^m$ to $17^h\ 0^m\ 12^s$ and from $17^h\ 45^m$ to $18^h\ 0^m$ only 5. Bright flashes of lightning occurred at $12^h\ 38^m\ 50^s$, $14^h\ 10^m$, and $15^h\ 55^m$.

The position of the Radiant was surprisingly well marked between 13^h and 14^h. It was about equidistant from ϵ and μ *Leonis* in Right Ascension $148^\circ{\cdot}0$, and North Polar Distance $66^\circ{\cdot}0$. No material deviation from this point was suspected; indeed, the persistence of the Radiant in the same spot in *Leo* was one of the most evident and striking features in the phenomenon.

Some few of the meteors were of considerable brilliancy,

but upon the whole they were not remarkable on the score of brightness. I should imagine it will be very difficult to identify any number of them at two or more stations.

Mr. Bishop, who carefully watched the meteoric shower at Weymouth, fixed upon 13^h local time for the maximum; this estimation, corresponding to $13^h\ 10^m$, Greenwich time, is in close agreement with the result obtained at Twickenham. At Weymouth some of the meteors had the characteristics of fireballs, leaving long trains of a greenish colour. The display commenced at $11^h\ 20^m$. Mr. Bishop was informed by Lieut. Baker, of H.M.S. *Lord Clyde*, in Portland Roads, that all the meteors appeared to him to radiate from a centre 20° above the horizon, and due east (for maximum time), which he also considered to be 13^h. In Malta Harbour, on board H.M.S. the *Prince Consort*, the maximum was judged to have taken place at $14^h\ 15^m$ local time, or at $13^h\ 19^m$ mean time at Greenwich.

Accounts of the Meteors of 1866, November 13–14, were also received from—

Mr. J. Birmingham, at Millbrook, Tuam. The position of a starlike and stationary meteor in about R.A. $10^h\ 2^m\ 30^s$ and N.P.D. [illegible], is referred to as seeming to mark the radiant-point. The number of meteors counted up to $12^h\ 50^m$ was [illegible], but from that time the counting could no longer be depended upon. The meteors are described as having the nuclei generally red or deep orange, while the tails were greenish or bluish, and often left a line of vapour in their place after their extinction. In one instance this smoky streak began instantly to move sideways at right angles to its motion when luminous; and in another, where it formed a considerable mass, it curled up in a crescent that for a short time continued its forward course very slowly and then as slowly retrograded: it was observed plainly for half-an-hour, and might have been visible longer.

The Rev. A. W. Dyer, Alton, Hampshire. The number of meteors as counted by himself and a friend, on the north and south side of a great circle through the zenith and the head of Leo were—

On south side } from 1^h to 1^h 5^m {219, 137} = 356; 1^h 10^m to 1^h 15^m {265, 220} = 485
On north side }

On south side } from 1^h 40^m to 1^h 45^m {85, 56} = 141.
On north side }

Two meteors occurring at 1^h 20^m and 1^h 26^m 5^s are particularly noticed.

Mr. V. Fasel, at Dr. Wrigley's Observatory, Clapham. The meteors were observed on the nights of November 12 and 13. The following table shows the numbers seen in successive half-hours:—

November 12, from	6 0	to	11 0	P.M.	7
	11 0	,,	11 30		9
	11 30	,,	12 0		12
November 13, from	0 0	,,	0 30	A.M.	72
	0 30	,,	1 0		263
	1 0	,,	1 30		724
	1 30	,,	2 0		394
	2 0	,,	2 30		61
	2 30	,,	3 0		56
	3 0	,,	3 30		22
	3 30	,,	4 0		32
	4 0	,,	4 30		34
	4 30	,,	5 0		12
	5 0	,,	5 30		9
					1708

the estimated number being about four times as many. The characteristics of the maximum display are stated to be as follows:—

1. The general direction of the meteors was from east to west. Those which originated east of the radiant point moved from west to east. The radiant point was about the centre of the "sickle" in *Leo*.

2. The meteoric trains of light were remarkably brilliant, and many of them of the shape of a spindle or as the vibrating of a string, being brighter in the middle of their path.

3. The greater number of the meteors were very bright, and in some instances as large as the planet *Jupiter*. Their colour was yellow, orange, and sometimes red, while the luminous paths were of an emerald green or bluish hue, though in some cases red.

4. The trains were of two kinds; either of a continuous line of light, or presenting the appearance of a luminous dust or sparks.

5. The duration of the appearance of the trains was, both in the east and west, from 2 to 14 seconds, in a few instances longer.

6. The longest and most brilliant trains were towards the west, varying from two to twenty degrees in length. Those in the east were comparatively short, about two or three degrees, but the duration of their appearance was quite as long as that of the former.

The author directs attention to the fact that after 2^h a.m. and after *Leo* had got up pretty high above the horizon, the meteors seen by him from that time, though apparently originating from the same radiant-point, took a different course, mostly tracing their trajectories from S.S.E. to N.N.W. and N. by W. as it were towards the direction of the Magnetic Pole.

Mr. Fasel's paper was accompanied by an elaborate tabular account of 89 of the most remarkable meteors observed on the night of the 13th.

The Rev. F. Howlett, Hurst Green, Canterbury. The number of meteors fairly counted by himself and a companion from $11^h\ 54^m$ p.m. to $2^h\ 40^m$ a.m. was upwards of 5600. The numbers at the highest period, the eight minutes from $1^h\ 2^m$ to $1^h\ 10^m$ a.m., averaged 200 per minute. No meteors were observed of any unusually great size. The colours of the nuclei were mostly *bluish white* tint, except when near the horizon they appeared of an orange or reddy tint. The *trains* were generally of a *greenish-white hue*, except for the last two degrees or so, which at the moment of explosion assumed a reddy appearance. The author refers to a list of *paths* submitted by him to the "Committee for the Observation of Luminous Meteors," in connexion with the British Association.

Mr. S. Hunter, at Sandy Cove, Kingstown, Dublin. The author was assisted in the observations by three friends, and he has recorded in a tabular form the particulars of 22 of the most remarkable meteors, and remarks. During a portion of the time in which the meteors were most brilliant he paid particular attention to the "Radiant Point," and thought it very near the intersection of a perpendicular dropped from ε *Leonis* to a line joining γ with the star marked x by the B.A. Maps.

Mrs. Hannah Jackson, at Brompton. Number of meteors counted from $11\frac{3}{4}^h$ p.m. to 1^h a.m. [illegible].

Rear-Admiral Eras. Ommaney, at Paddington. The Radiant Point is described as developing itself in a most remarkable degree of accuracy; soon after the commencement of the shower, about the centre of a trapezium of stars, on the "sickle" in *Leo*, two distinct flashes were observed without any path or lateral motion, and around this point the meteors seemed to emerge with longer or shorter paths, according to the distance of their emergence from the radiant point. At about 1 a.m. a remarkable phenomenon was observed on the radiant-point in the shape of a bright golden-coloured flash, having a zigzag form, the extent limited to about 1° in arc, and visible for a second in time.

Mr. Taunton, at Ashley, near Stockbridge, Hampshire. Meteors counted, 1420 in $2\frac{1}{2}$ hours. Some appeared only as a ball, without a track or train; many were small and faintly visible; many largé, silvery and of slower pace, in one of these the author imagined that he saw a dark spot in its lamp; it flew from east to north, crossing the Great Bear.

The Rev. G. Venables, at Broadwater Rectory, Sussex. Number of meteors counted by himself and a friend, standing north and south, between $11^{h}\ 35^{m}$ and $11^{h}\ 45^{m}$, was 610. The author was much impressed with the fact that some of the large meteors disappeared after a pretty straight course through a considerable space in the heavens, and reappeared perhaps 8 to 10 degrees further on, continuing the same course. Two other things impressed him; one was that the train is a *reality*, and not an optical illusion, such as might be produced by rapidly revolving a burning brand: the second was, that in the trains which continued a length of time a deflection occurred; he had noticed this before in the trains of ordinary meteors: the deflection was not curved, but rigid, just like a stiff stick broken in the middle.

The annexed diagrams were also received from the Astronomer Royal and from Mr. A. S. Herschel.

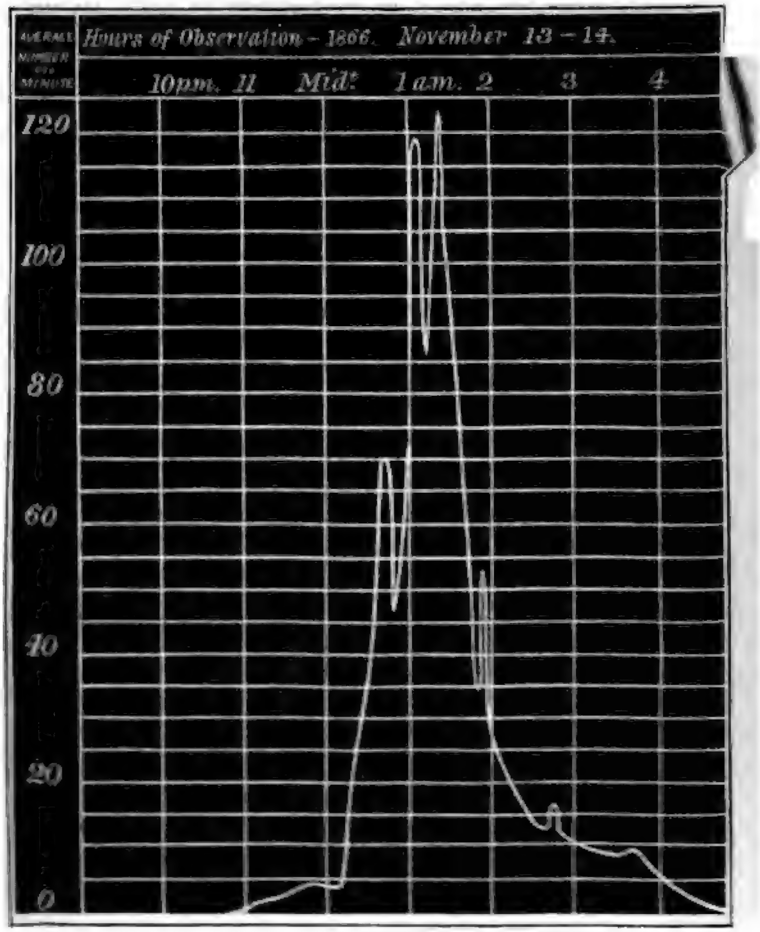
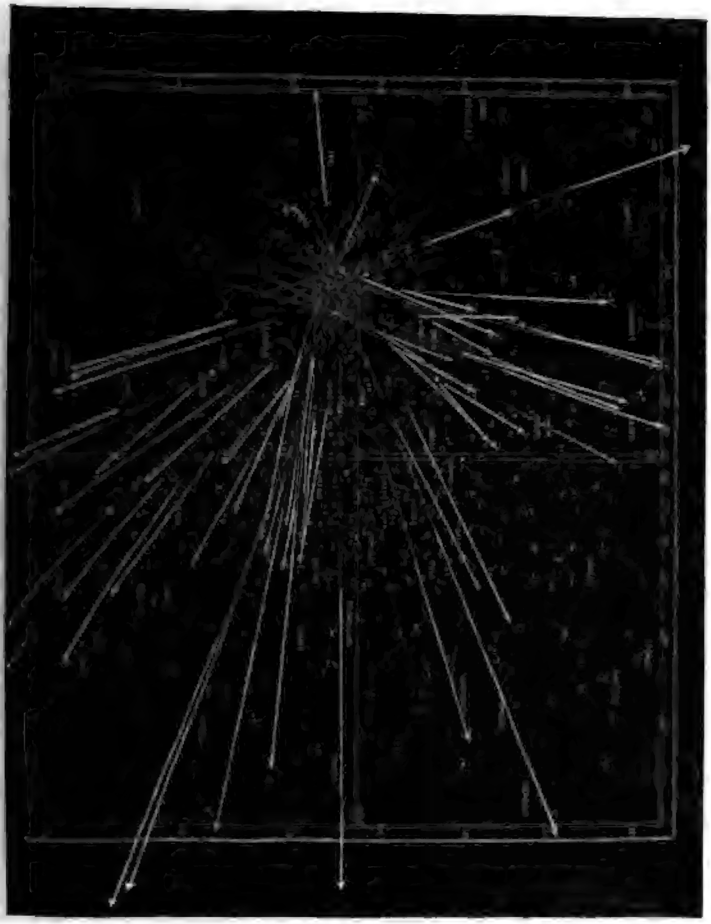


Diagram showing the Average Number of Meteors per Minute observed at the Royal Observatory, Greenwich, Nov. 13–14, between the hours 11 p.m. and 4 a.m.



Tracks of Meteors observed at the Royal Observatory, Greenwich, 1866, Nov. 13–14.

Tracks of 83 Meteors observed at the Observatory. Glasgow, 1866, Nov 14, 1^h 55^m a.m. to 3^h 40^m a.m. by A. S. Herschel and H. McGregor, showing the position of the Radiant Point in R.A. 149° N.D. 24°. N.B. A stationary Meteor, shown by a ✱, was seen very near the radiant point.

Remarks on certain Observations of T *Coronæ, reputed to have been made by Mr. Barker, on May* 4, 8, 9, *and* 10, 1866. By E. J. Stone, Esq.

The interest excited by the late outburst of the variable T *Coronæ* is so great, and a knowledge of its brightness, previous to May 12, so important for a right understanding of that phenomenon, that I have thought it right to probe the reality of certain observations reputed to have been made by Mr. Barker, of London, Canada West, on May 4, 8, 9, and 10. In his letter, published in the *Free Press*, of May 16, Mr. Barker referred to his observations of May 14, but made no mention whatever of any observations made previously to that date. I must confess, therefore, that I was much surprised to find from Mr. Hind's letter to the *Astr. Nach.* 1601, that Mr. Barker afterwards claimed to have seen the variable with the naked eye as early as May 4. The circumstances connected with the publication of the observations of May 4, 8, 9, and 10, were, to say the least, most anomalous. Mr. Barker's language, however, was so precise that I thought it best to write to him for references to his earliest publication of the observations made previously to May 14. To that letter I received the following reply:—

"*London, Canada, 28th August*, 1866.

"Sir,—I am in receipt of your letter requesting me to send you the date I first made public my discovery of variable star *Corona Borealis*.

"I regret to say, that though I discovered it on the 4th of May last, I did not publish it in the newspapers till the 15th of that month, when I caused it to be published in the *Evening Advertiser* newspaper of this city. On the following morning it was published in the *Free Press*, of which I sent a copy to Sir John Herschel. I also sent a copy of the *Advertiser* to Professor Watson, Ann Arbor University, Michigan, U.S.

"It was by mere accident that I published the matter in the newspapers at all; and my sole reason for doing so at the time was in consequence of its rapid diminution, and fearing that it might disappear before being seen by any prominent astronomer. I had drawn up, however, a full statement of my observations from the first discovery of it; but the newspaper people, although not refusing to publish, intimated to me that it was desirable to make the article as short as possible, as such subjects were not interesting to the general public. Hence the very short notice published by me. Had I anticipated that so much interest would be taken in regard to the star I should have been more explicit.

"However, finding the star declining so rapidly on the 15th and 16th,—it having decreased to the $3\frac{1}{2}$ magnitude on the

latter evening,— I, on the 17th May, wrote to Mr. Watson, Professor of Astronomy at Ann Arbor University, giving full particulars of my discovery from the first. I may here mention that I wrote that letter to Mr. Watson at least three weeks before any advice had been received from England of its discovery there, and before I anticipated any question as to the date of my discovery.

"Mr. Watson replied to my letter, and his answer thereto, with my own observations, I sent to J. R. Hind, Esq., and I find by your letter that that gentleman had sufficient reliance upon my statements to have them published in the journal you referred to (the *Astr. Nach.*).

"I regret exceedingly that I did not publish an account of the discovery earlier, more in the interest of science than for my own sake; though I feel much gratified in having been, as I sincerely believe, the first discoverer of this star as a variable one.

"I will now give you all the particulars I can.

"On the 4th of May, between 9 and 10 P.M., I was observing the stars, and saw a strange one near Epsilon *Coronæ*, of about the same magnitude, but a little brighter. For three nights afterwards the weather was bad, and I did not take any observations.

"On the nights of the 8th and 9th, though the weather was still hazy, I observed that the star had increased very much in magnitude.

"On the 10th the atmosphere was clear, and the star shone conspicuously above all the stars in its vicinity; it was brighter than *Alphecca*, and fully of the second magnitude, of a reddish colour, but not so much so as *Antares*.

"I looked at it for fully an hour through the telescope,— a 4-inch by Cook. It had a steady light, with a slight halo. The light was not flickering like that of *Antares*.

"I continued to observe it every night until the 20th, when it could no longer be seen by the naked eye, having gradually decreased from the second to the sixth magnitude; the halo decreasing with the star. On the latter evening I observed it with a power of 133, when it showed a well-defined disk of a beautiful gold colour, without the slightest haze.

"I would make a remark with regard to the suggestion of Mr. Huggins as to its being a world in combustion or in candescence. This star has been well known for years as one of the $9\frac{1}{2}$ magnitude; and after its late temporary change in its condition and appearance, it has returned to its original state, there being now no apparent difference in its size or brilliancy from what it was when first discovered. Under these circumstances, I cannot believe that it has been in a state of combustion or dissolution, which would necessarily involve a change in its appearance.

"I inclose herewith several letters from gentlemen to whom

I communicated my discovery, which you can make such use of as you think proper.

"Should the Astronomical Society take any notice of this communication, I shall be obliged if you will let me know the result.—I am, Sir, &c. "WM. BARKER,

"Customs Department, London,
Canada West.

"*E. J. Stone, Esq.*,
"*Sec. of R. A. S. of London.*"

In Mr. Barker's letter one statement was made which appeared to me capable of being used as a test of the reality or otherwise of Mr. Barker's earlier observations. The statement alluded to is as follows:—"I, on the 17th of May, wrote to Mr. Watson, Professor of Astronomy at Ann Arbor University, giving *full particulars of my discovery from the first.*" Now, if on May 17 Mr. Barker had written to Professor Watson full particulars of his observations of May 4, 8, 9, and 10, I for one should have accepted, without the slightest doubt, these observations as real. He could not at that time have been informed of the observations of other persons.

I therefore wrote to Professor Watson, asking him either to have the kindness to supply me with a copy of Mr. Barker's letter, or to state explicitly whether there was in that letter of May 17 any reference to the reputed observations of May 4, 8, 9, and 10. To that letter I have received the following reply:—

"*Astronomical Observatory,*
"*Ann Arbor, Nov.* 5, 1866.

"Dear Sir,—I regret to say, in reply to your letter of the 17th ult., that I am unable to furnish you with a copy of Mr. Barker's letter to me in regard to his observations of the new variable in the *Corona*. About a month ago, Mr. Barker applied to me for this letter, and I returned it to him, as requested, without preserving a copy. I can, however, state positively that he did not mention any actual observation earlier than May 14th. He said that he thought he had noticed a strange star in the *Crown* about two weeks before the date of his first observation (May 14th), but not particularly, and that he did not recognise it until the 14th. He did not give any date, and did not even seem positive as to identity. There was no statement in the letter that he had seen it on the 4th, 8th, 9th, or 10th. On the contrary, he gave the date May 14th as his first observation, with a supposition that he had seen it about two weeks earlier. The latter he expressed as merely a conjecture, and that if true his recollection was that the brilliancy was equal to *α Coronæ*.

"If his letter of the 17th of May, addressed to me, is the only evidence on record which he has made of his observations, the reputed observations of May 4, 8, 9, and 10, are fictitious. I think that he stated in the same letter that he sent a similar notice to the Astronomer Royal and also to Sir John Herschel.

"When I returned the letter of May 17th, I made an en dorsement across the first page, in regard to its genuineness and attached my signature.

"I regret that I did not preserve a copy of the letter question; but if the original is produced, it will appear th my recollection of its contents is correct.

"Very truly yours,
"JAMES C. WATSON,
"Director of the Observatory.

"*E. J. Stone, Esq.*,
"*Sec. of R.A.S.*
"*London, England.*"

I think that, after this letter, no one will be inclined to l much stress upon Mr. Barker's reputed observations of May 8, 9, and 10.

I may mention that, with his letter, Mr. Barker enclos three letters purporting to be written by three gentlemen position in London, Canada West; but these letters really on amounted to this, that the writers believed Mr. Barker to be man of truthfulness and honour, and that he had said som thing to them about some new star somewhere in *Coron* some time in an early part of May. Such vague statemen really prove nothing.

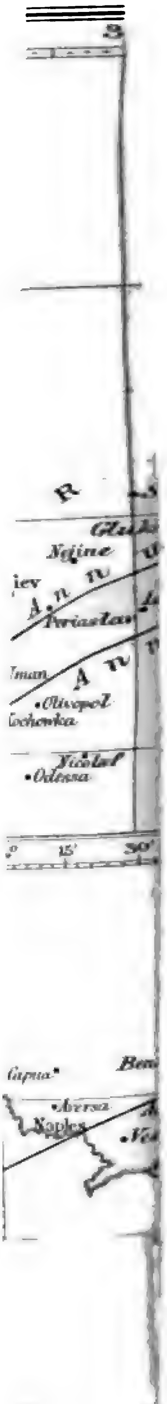
In addition to the strong negative evidence of Dr. Schmic Mr. Baxendell, and others, particularly of Dr. Schmidt, th the variable was certainly not a conspicuous object to tl naked eye previously to May 12, we have the remarkab fact that, on May 12 and the three following days, the variab was independently discovered by no less than seven differe persons. With this fact before me, I cannot help believing th it would have been almost impossible for the star to have be overlooked from May 4 to May 12, had it then been as brig as stated by Mr. Barker.

I have not the slightest hesitation in stating that, in n opinion, Mr. Barker's observations previous to those made May 14 are not entitled to the slightest credit.

The Annular Solar Eclipse of March 5–6, 1867. By J. R. Hind, Esq.

The Astronomer Royal having suggested to me the exp diency of circulating a map of the path of annular phase in tl eclipse of 1867, March 5–6, the accompanying chart has be prepared by Mr. Farley from the elements of the eclipse giv in the *Nautical Almanac*. It exhibits the limits of annulari from the western coast of Africa to the eastern part of Euro and on an enlarged scale that portion of the path which cros Italy.

The lines on the map were laid down from the followi



Nejine
Periaslav
Olivopol
Odessa
15'
30'
Capua
Aversa
Naples

calculated positions, adapted to the semi-diameters of the *Nautical Almanac*:—

Greenwich M.T.		Northern Limit. Long.	Northern Limit. Lat.	Central Line. Long.	Central Line. Lat.	Southern Limit. Long.	Southern Limit. Lat.
1867.	h m	° ′	° ′	° ′	° ′	° ′	° ′
Mar. 5	20 48	W. 10 51	N. 33 45	W. 9 48	N. 33 10	W. 8 49	N. 32 34
	20 51	8 20	34 1	7 25	33 27	6 33	32 53
	20 54	6 7	34 19	5 18	33 46	4 32	33 13
	20 57	4 7	34 39	3 23	34 7	2 41	33 35
	21 0	2 18	35 1	W. 1 37	34 29	W. 0 58	33 58
	21 3	W. 0 35	35 24	E. 0 2	34 53	E. 0 38	34 22
	21 6	E. 1 0	35 48	1 35	35 18	2 9	34 48
	21 9	2 30	36 13	3 3	35 44	3 35	35 14
	21 12	3 55	36 40	4 27	36 11	4 58	35 41
	21 15	5 18	37 7	5 48	36 39	6 18	36 9
	21 18	6 37	37 35	7 6	37 7	7 35	36 38
	21 21	7 54	38 4	8 22	37 36	8 49	37 8
	21 24	9 9	38 35	9 36	38 6	10 2	37 38
	21 27	10 23	39 6	10 49	38 37	11 14	38 9
	21 30	11 36	39 38	12 0	39 9	12 24	38 41
	21 33	12 46	40 10	13 11	39 42	13 34	39 14
	21 36	13 57	40 43	14 20	40 15	14 43	39 47
	21 39	15 7	41 17	15 30	40 50	15 51	40 21
	21 42	16 17	41 53	16 39	41 25	17 0	40 57
	21 45	17 27	42 29	17 49	42 1	18 9	41 33
	21 48	18 38	43 6	18 59	42 37	19 19	42 9
	21 51	19 50	43 44	20 10	43 15	20 29	42 46
	21 54	21 3	44 23	21 22	43 54	21 40	43 25
	21 57	22 17	45 3	22 35	44 34	22 53	44 5
	22 0	23 32	45 44	23 50	45 14	24 7	44 45
	22 3	24 50	46 26	25 7	45 56	25 23	45 26
	22 6	26 10	47 10	26 26	46 39	26 42	46 8
	22 9	27 33	47 55	27 48	47 23	28 4	46 52
	22 12	29 0	48 41	29 14	48 9	29 27	47 37
	22 15	30 30	49 29	30 43	48 56	30 55	48 23
	22 18	32 5	50 18	32 16	49 44	32 27	49 11
	22 21	33 46	51 9	33 56	50 34	34 5	50 0
	22 24	35 34	52 3	35 42	51 26	35 49	50 50
	22 27	37 31	52 58	37 35	52 20	37 40	51 43
	22 30	39 37	53 56	39 38	53 17	39 39	52 38
	22 33	41 53	54 56	41 51	54 16	41 48	53 35
	22 36	44 21	56 0	44 17	55 18	44 11	54 35
	22 39	47 8	57 9	47 0	56 24	46 51	55 38
	22 42	50 32	58 25	50 10	57 34	49 50	56 45
	22 45	54 27	59 47	53 48	58 51	53 16	57 56
	22 48	E. 59 17	N. 61 17	E. 58 16	N. 60 15	E. 57 24	N. 59 14

The mean duration of the annular phase on the central line is 2^m; the greatest is $2^m\ 4^s$; and the least $1^m\ 56^s$, about the times $20^h\ 48^m$ and $22^h\ 12^m$ respectively.

Nautical Almanac Office,
1866, *Dec.* 31.

On the Simultaneous Disappearance of Jupiter's Satellites in the year 1867. By G. B. Airy, Esq., Astronomer Royal.

It may be interesting to Members of the Society to be informed that there will be an opportunity in the year 1867 of observing that very rare phænomenon (hitherto observed, I believe, only twice, one of the observations being that of our Member the Rev. W. R. Dawes) of the simultaneous concealment of *Jupiter's* four satellites. On August 21 *Jupiter* will be without satellites for one hour and three-quarters; and, if the circumstances of the weather, &c., be favourable, all the four disappearances and the four reappearances may be observed in this country. I extract the following numbers from the *Nautical Almanac*:—

	Greenwich Mean Solar Time. h m	
1867, Aug. 21	8 14	The third satellite will enter on Jupiter's face. The Sun will not be very much depressed below the horizon, and Jupiter will not be very high, but this phænomenon may probably be seen. All these which follow may be seen well.
	9 9	The second satellite will be eclipsed in the shadow of Jupiter.
	9 28	The fourth satellite will enter on Jupiter's face.
	10 4	The first satellite will enter on Jupiter's face.
		The four satellites will then be invisible.
	11 49	The third satellite will pass off the disk of Jupiter.
	12 13	The second satellite will reappear from occultation behind the body of Jupiter (its emersion from the shadow having taken place behind the body).
	12 23	The first satellite will pass off the disk.
	13 54	The fourth satellite will pass off the disk.

There will, as usual, be several instances of simultaneous concealment of the three interior satellites; namely, August 14, $8^h\ 20^m$ to $8^h\ 33^m$ (difficult to observe); August 28, $11^h\ 47^m$ to

$14^h\ 6^m$; and September 4, $14^h\ 45^m$ to $15^h\ 50^m$. But in these instances, the fourth satellite will not be hidden.

Royal Observatory, Greenwich,
1866, *December* 5.

Observation of the Occultation of Aldebaran, 1866, *Nov.* 22. By John Joynson, Esq.

(*Communicated by John F. Stanistreet, F.R.A.S.*)

The occultation of *Aldebaran* by the Moon last night was observed satisfactorily, considering that the star was so much dimmed by hazy clouds.

At the disappearance the star was seen to slide on to the disk, and had passed the apparent limb a second and a half before it disappeared. The reappearance was quite instantaneous.

	h m s	
Disappearance	9 54 57·9	+ 1·5 G.M.T.
Reappearance	10 53 11·7	

The chronometer error was determined by the transit of *ζ Pegasi.*

Latitude	+ 53° 28′ 24″
Longitude	− $0^h\ 12^m\ 6^s·9$

Waterloo, near Liverpool, 23 *Nov.*, 1866.

Occultations of Stars by the Moon, observed 1866, *Nov.* 20. By W. Noble, Esq.

ξ Arietis disappeared instantaneously at the Moon's dark limb at

$22^h\ 55^m\ 35^s·5$ L.S.T. = $6^h\ 57^m\ 21^s·7$ L.M.T.

and reappeared at the bright limb at

$23^h\ 56^m\ 51^s·9$ L.S.T. = $7^h\ 58^m\ 28^s·1$ L.M.T.

B.A.C. 755 disappeared at the Moon's dark limb *not quite* instantaneously at

$23^h\ 46^m\ 34^s·2$ L.S.T. = $7^h\ 48^m\ 12^s·1$ L.M.T.

This star was at some distance from the Moon's bright limb on emersion before I perceived it. Power 135 (a positive eye-piece) adjusted on the respective stars with my Ross Equatoreal of 4·2 inches aperture and 61 inches focal length.

Forest Lodge, Maresfield, Sussex,
December 14, 1866.

In the announcement in the last Number as to the Johnstone Memorial Prize, instead of *Star Parallax* read *Solar Parallax.*

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MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. XXVII. *January* 11, 1867. No. 3.

Rev. CHARLES PRITCHARD, President, in the Chair.

Edward William Brayley, Esq., London Institution;
Richard Hooke, Esq., Higher Broughton, Manchester;
Benjamin Loewy, Esq., Observatory, Kew;
Rev. James Parkes, Stockport;
William Osborne, Esq., York; and
Thomas Warner, Esq., Sussex Square, Brighton,

were balloted for and duly elected Fellows of the Society.

On the Meteoric Shower of November 13–14. By G. W. H. Maclear, Esq., Second Assistant at the Royal Observatory, Cape of Good Hope.

I have the honour to report for the information of the Royal Astronomical Society the results from the watches kept up on the 12th, 13th, and 14th instants, for observing the expected meteors or shooting stars.

The station selected was on the roof of the west wing of the Observatory.

On the night of the 12th 76 were observed (see Table I.)

On the night of the 13th, between 10^h and 13^h, Cape mean time, we noted 33 in various parts of the heavens. At $13^h\ 3^m$ the shower commenced, one from above *Regulus*, darting up towards the zenith, of a fine orange colour with a long

greenish train, followed, a few minutes after, by a second, of a bright red, vanishing near *Mars*.

As the constellation *Leo* rose, the meteors appeared in greater numbers, three, four, and seven at one discharge, stretching from *Leo* across the zenith, to *Fomalhaut* in the west, some shooting ahead of those that had preceded them; the prevailing colour appeared to be orange, with a long sea-green train; others were of a deep red, like balls of fire, without any train at all.

Some meteors would start as small as a star of the fourth or fifth magnitude, but on reaching the zenith would assume a brilliancy equal or superior to that of *Venus*, the majority going to the W. and S.W.

When the meteors first appeared, we noted the times and vanishing points as near as possible; but at $13^h\ 46^m$ the shower became so thick, that we were compelled to note merely the number that fell in two, three, or ten minutes, as we had an opportunity of looking at the chronometer, counting in concert.

The shower reached its maximum about 14^h, when between $14^h\ 10^m$ and $14^h\ 13^m$ we counted no less than 200 meteors of various sizes.

It was impossible at this time to note any special peculiarities, excepting one meteor about 14^h which commanded attention; starting from *Regulus*, and travelling horizontally towards the south, it threw off in its passage flakes of light like drops of liquid fire.

At $14^h\ 41^m$ the numbers decreased rapidly, the smaller ones being probably lost in the approaching daylight. The last noted, a very fine one, was at $16^h\ 21^m\ 15^s$, disappearing near η *Argus*.

The total number of meteors noted between $13^h\ 3^m$ and $61^h\ 21^m$, amounted to 2742, in addition to the 33 previously observed, 2775 between 10^h and $16^h\ 21^m$. (See Table II.) It is difficult to fix upon any particular Radiant Point, they appeared to rise from all parts of the constellation, and though many undoubtedly rose from near μ, it appeared to us that the majority were from nearer *Regulus*, and about η.

On the night of the 14th only 24 meteors were observed (see Table III.)

Table I.

Meteors observed on the Night of the 12th November, 1866, at the Royal Observatory, Cape of Good Hope.

Cape M T. h	m	Obsd.	Direction from	to	Remarks.
10	25	1	Orion	N.W	4th Mag.
11	22	1	Eridanus	N.	Long Train.
					4 Mag.
	24	1	,,	,,	3 Mag.
	26	1	Orion	,,	4 Mag.
	30	1	Aldebaran	,,	
	34	1	Eridanus	W.	Long Train 2°.
	35	1	,,	,,	
	42	1	Taurus	N.E.	2nd Mag. very
	49	1	Cetus	S.W.	long train, burst like arocket.
	50	1	Eridanus	N.	
	51	1	,,	,,	
	54	1	Orion	N.	
11	57	1	,,	,,	
12	4	1	Eridanus	,,	
	6	1	Pleiades	,,	
	11	1	Canopus	N.E.	Cloudy south.
	18	2	Eridanus	N.W.	3rd Mag.
	23	1	Larg. Mag. Cl.	N.	2nd Mag.
	25	1	Eridanus	S.	
	28	1	Fomalhaut	W.	
	34	1	Eridanus	S.	
	36	1	,,	,,	2nd Mag.
	38	1	Pleiades	N.	
		1	Eridanus	,,	
	42	1	Aquarius	S.W.	
		1	Orion	W.	
	49	1	,,	E.	
	51	1	Achernar	S.W.	
	52	1	β Ceti	Achernar	Very brilliant, large as Venus.
	54	1	Rigel	W.	
	55	1	Cetus	N.	
12	56	1	Procyon	N.	
13	0	1	Eridanus	N.	
	4	1	Orion	E.	

Cape M.T. h m	Obs.	Direction. from	to	Remarks.
13 6	1	Procyon	N.	
	1	,,	S.	
9	1	Sirius	W.	
15	1	Eridanus	S.W.	
16	1	Cetus	E. to W.	
18	1	Achernar	Larg. Mag. Cl.	
21	1	Canopus	S.E.	
22	1	Larg. Mag. Cl.	W.	
27	1	Sirius	S.E.	Brilliant.
36	1	Pleiades	N.	
42	1	Smal. Mag. Cl.	E. to W.	
,,	1	,,	S.	
43	1	Pleiades	S.E.	
44	1	Orion	N.W.	
46	1	Castor	N.	
	1	Capella	N.	
50	1	Canopus	W.	
54	1	Mars	N.	
57	1	Canopus	S.S.E.	
58	1	Aldebaran	N.N.W.	
13 59	1	Eridanus	W.	
14 0	1	Cetus	S.W.	
4	1	Taurus	S.W.	
5	1	Achernar	Small Mag. Cl.	
10	1	Larg. Mag. Cl.	β Hydræ	
18	1	Hydra	N.W.	
21	1	Canis Maj.	S.	
22	1	Orion	W.	
28	1	Hydra	E.	
30	1	Pollux	Mars	
41	1	Gemini	N.W.	
44	1	Mars	N.W.	
	1	Castor	N.E.	
45	1	Rigel	Castor	Very brilliant.
	1	Hyades	W.	
56	1	Orion	W.	
14 58	1	Canopus	S.	
15 0	1	Mars	S.	
4	1	Sirius	W.	
11	1	Gemini	Mars	
15 12	1	Sirius	α Orionis	

Total 76.

Table II.

Meteoric Shower of November 13th, 1866.

Cape M.T. h	m	s	No. Obsd.	Direction from	Direction to	Colour.	Remarks.
10	5	0	1	Pleiades	α Androm.	Blue and white	Large.
11	5	0	1	Sirius	α Orionis		Small.
	6	0	1	Pleiades	Perseus	..	”
	20	0	1	ι Argus	W.	..	”
	24	0	1	”	S.	..	”
			1	Sirius	S.E.	..	”
	27	0	1	Aldebaran	Pleiades	..	”
	30	0	1	α Orionis	N.E.	..	”
	32	0	1	Pleiades	Aldebaran	..	Curved.
	33	0	1	Orion	Aldebaran	..	Small.
	35	0	1	N.E. Mag. Maj.	Canopus	..	”
	39	0	1	Columba	Canopus	..	”
	43	0	1	Procyon	Castor	..	”
	45	0	1	”	α Columbæ	..	”
	46	30	1	α Orionis	Procyon	..	”
	55	0	1	Argus	S.	..	”
	57	0	1	ι Can. Maj.	ι Argus	Red and orange	Large.
	57	30	1	Argus	S.	..	Small.
12	0	0	1	Below ι Can. Maj.	S.	..	”
	4	0	1	” Canopus	E.	..	”
	6	0	1	” Argus	S.	..	”
	7	0	1	” Sirius	S.E.	Blue	Large.
	10	0	1	” Can. Maj.	N.E.	..	Small.
	15	0	1	” Orion	”	..	”
	21	0	1	ι Argus	Horizon	..	”
	25	0	1	Above Procyon	N.	..	”
	26	0	1	Achernar	W.S.W.	..	”
	29	0	1	ι Argus	Horizon	..	”
	48	0	1	Orion	Aldebaran	..	”
	57	0	1	Can. Min.	ι Argus	..	”
	58	0	1	Hydra	Southern Cross	..	”
13	0	0	1	β Hydræ	S.	..	”
	1	0	1	Castor	α Persei	..	”
	3	0	1	Above Regulus	α Hydræ and Zenith	Orange, green train	Long train
	12	0	1	Mars	Regulus	Orange and white	
13	13	0	1	Below Leo	Mars nearly		

Cape M.T. h m s	No. Obs.	Direction from	to	Colour.	Remarks.
13 14 0	1	Below Castor	Leo		
15 0	1	„ Mars	Fomalhaut	Very long train	
17 0	1	Regulus	S. Cross	Head orange	
18 0	1	„	„	Green train	
21 0	1	Below Leo	S.	Beautiful	„
22 0	1	„	Below Castor	„	„
24 0	1	„	S. Cross	White globe	No train.
24 30	1	Leo	α Hydræ		
25 0	1	Leo	Below Pollux		
26 0	1	Horizon below Leo	S. Cross	Red	Ball.
27 0	3	3 do.			
27 30	2	2 „			
27 45	1	1 „			
28 0	1	1 „			
28 0	2	Leo	S.W.		
29 0	3	„	„		
29 30	1	„	„		
	1	„	N.		
30 0	1	„	S.W.		
	2	„	Zenith		
31 0	1	„	„	..	Slow without train
	2	„	„	..	Long train
31 30	4	„	N.		
33 0	1	„	„		
	1	„	„		
	1	„	S.		
33 30	1	„	„		
	1	„	S.W.		
34 0	6	„	S.W.		
35 0	1	„	N.		
	1	„	S.E.		
35 20	1	„	S.W.		
35 40	1	„	N.W.		
35 50	1	„	W.		
36 0	1	S. Cross	S.		
36 30	1	N.	Regulus		
36 40	1	N.W.	W.		
37 0	1	Leo	W.		
	1	„	S.W.		
38 0	1	„	„		
13 38 5	1	„	„		

Cape M.T. h m s	No. Obs.	Direction from	to	Colour.	Remarks.
13 39 0	1	Leo	Sirius		
"	1	"	Perseus		
"	2	"	N.		
"	1	"	S.W.		
"	3	"	Mars		
"	3	"	N.		
"	1	"	Pleiades		
"	1	"	Mars		
"	1	"	Procyon		
"	6	"	"		
"	1	"	Horizon to N.		
"	1	"	α Centauri		
"	1	"	S. Cross		
"	1	"	α Persei		
"	1	"	Pleiades		
"	3	"	W.		
40 0	5	"	Fomalhaut		
"	1	"	Argus		
"	1	"	Canopus		
"	1	"	Perseus		
43 0	4	"	W.		
"	3	"	S.W.		
"	2	"	Perseus		
"	2	"	N.W.		
"	1	"	Zenith		
"	1	"	N.	Orange head, green train	
"	1	"	Canopus		
"	1	"	S.		
44 0	4	"	N.		
44 30	6	"			
"	3	"	1 S., 1 S.E., 1 N.		
"	1	"	S.		
45 0	3	"	S.		
"	1	"	Zenith		
"	1	"	N.		
"	2	"	Mars		
"	2	"	W.		
"	1	"	S.W.		
"	1	"	W.		
"	2	"	S.		
"	1	"	W.		
"	1	"	S.		
13 46 0	1	"	W.		

Cape M.T.	No. Obs.	Direction from	to	Colour.	Remarks.
h m s					
13 46 0	1	Leo	N.		
,,	1	,,	W.		
,,	1	,,	Zenith		
,,	4	,,	W.		
,,	9	,,	,,		
47 0	2	,,	N.W.		
,,	1	,,	Horizontal to S.		
,,	2	,,	S.		
,,	1	,,	N.W.		
,,	2	,,	S.		
,,	1	,,	S.W.		
,,	2	,,	W.		
,,	1	,,	N.W.		
,,	1	,,	S.		
,,	3	,,	S.W.		
,,	1	,,	N.		
,,	2	,,	S.W.		
49 0	1	,,	N.		
,,	2	,,	N.W.		
,,	1	,,	W.		
,,	1	,,	Zenith		
,,	1	,,	N.W.		
,,	1	,,	S.		
,,	1	,,	S.W.		
,,	1	,,	S.		
,,	1	,,	N.		
,,	2	,,	W.		
,,	1	,,	S.W.		
,,	1	,,	S.		
,,	1	Argus	S.E.		
,,	3	Leo	S.W.		
,,	4	,,	N.W.		
,,	1	,,	W.		
,,	1	,,	Mars		
,,	2	,,	S.		
,,	1	,,	Zenith		
13 51 0	1	,,	S.		
,,	14	,,	W. and N.W.	Orange and green	Splendid.
,,	1	,,	N.W.		
,,	1	,,	S.W.		
,,	1	,,	N.W.		
,,	1	,,	Zenith		

Cape M.T. h m s	No. Obs.	Direction from	to	Colour.	Remarks.
13 51 0	1	Leo	N.W.		
„	1	„	S.		
„	2	„	N.W.		
„	1	„	S.W.		
„	1	„	„	..	Horizontally.
„	1	„	S.W.		
„	4	„	S.		
„	3	„	S.		
„	2	„	W.		
„	5	„	S.		
„	17	„	S.W. and W.		
„	31	„	„		
54 0					
	36	„	„		
55 0					
	51	„	„		
57 0					
	30	„	„		
13 58 0					
	469	„	„		
14 8 0					
	100	„	„		
10 0					
	100	„	„	..	Shower at its maximum.
11 50					
	100	„	„		
13 0					
	100	„	„		
15 40					
	100	„	„		
18 0					
	100	„	„		
20 30					
	100	„	„		
23 0					
	100	„	„		
26 30					
	100	„	„		
30 0					
	100	„	„		
34 0					
	100	„	„		
36 45					
	100	„	„		
41 35					
	100	„	„		
47 0					
	100	„	„		
53 0					
	100	„	„		
14 59 0					
	100	„	„		
15 8 0					
	100	„	„		
21 0					
	100	„	„		
40 30					
	50	„	„		
15 57 0					
	14	„	„		
16 10 15					
	1	„	„		
16 21 15					

TABLE III.

Meteors observed at the Royal Observatory, Cape of Good Hope, on Nov. 14th, 1866.

Cape Mean Time. h m	No. of Obs.	Direction From	To	Colour.	Remarks.
11 22	1	Taurus	N.		
11 37	1	,,	,,		
11 40	1	Sirius	S.E.	...	Brilliant
11 41	1	Hyades	N.W.		
11 47	1	Sirius	N.E.		
12 0	1	Canopus	S.		
12 22	1	Castor	E.		
12 22	1	Canopus	S.		
13 17	1	Orion	E.		
14 5	1	Procyon	E.		
14 18	1	Cetus	W.		
14 20	1	Argus	S.E.		
14 22	1	Mars	E.		
14 25	1	Castor and Perseus			
14 37	1	Mars	N.N.E.		
14 42	1	Hydra	E.		
14 46	1	Regulus	E.		
14 51	1	Orion	E.		
14 52	1	Mars	E.		
15 10	1	β Ceti	W.		
15 17	1	Centaurus	S.	...	Brilliant
15 20	1	Leo	N.W.		
14 30	1	Castor	E.		
14 30	1	Eridanus	W.		

Total 24.

Maximum and Minimum Temperatures.

Nov. 10	83°·8	57°·2
11	85·2	62·2
12	72·0	60·6

Nov. 13	71°·2	57°·3
14	75·2	59·6
15	72·7	55·0
16	61·0	50·0

On the Luminous Meteors of November 13–14, 1866. By Professor Challis.

The extraordinary display of meteors on November 13, was observed by me at the Cambridge Observatory in conjunction with Professor Adams and his assistants Mr. Graham and Mr. Todd. Intending to devote myself principally to the determination of apparent positions, I had prepared a small wooden instrument, which I call a "meteoroscope," which was fixed to a tripod stand, and was furnished with a straight bar for pointing, 21 inches long, and readily movable in altitude and azimuth. The movements of the bar were read off by indices from a vertical arc and a horizontal circle, which I graduated for the occasion to integral degrees. The observers were all situated on the flat roof of a detached out-building, which commanded the whole of the heavens except a small portion southward, which was intercepted by the Observatory building. As there were two meteoroscopes in use, it was agreed to divide the heavens into northern and southern halves, and as I took the northern half, my observations were generally restricted to that portion, excepting when it was covered by cloud. At the first sight of each meteor whose position I observed, I called out "Now," and Mr. Todd gave out the time, having before him a mean time chronometer, which served for the observations with both meteoroscopes. I then pointed the bar to the estimated place of the meteor, read off the altitude and azimuth angles, and mentioned the magnitude, direction of flight, and incidental physical circumstances. These data, with the time, were recorded by H. Wilberforce Clarke, Esq., R.E., of Chatham, who kindly volunteered to assist on the occasion. In this manner I obtained 63 positions of meteors, with 7 positions of stars, the latter being taken in order to serve for correcting for error of position of the axis of the instrument, which did not admit of being adjusted vertically by a spirit-level. The true altitudes and azimuths of the meteors have been calculated from the recorded angles with as much exactness as the rude nature of the observations allowed of, and, together with the Greenwich mean times, have been communicated to Mr. Glaisher, in the hope that by comparison with observations made elsewhere they might be used for determining the actual courses of the

meteors and their heights above the Earth's surface. The observations were all made between $11\frac{1}{2}^h$ and $14\frac{1}{4}^h$. Many more might have been taken in the same time; but the meteors gradually became so numerous that I relaxed my efforts to get positions on account of the improbability that the same meteor would be observed at different localities. Also about 13^h clouds rose up from the north-west, and shortly covered the heavens, which continued clouded for about 20^m. I succeeded, however, in obtaining at $13^h\ 20^m$ the following observation, from which I have deduced a determination of the position of the Radiant Point.

At the time mentioned, which was noted roughly by means of my watch, regular observations not having recommenced, I saw a meteor which for an instant was stationary, and quickly after another at the same altitude and a little more northward, but smaller than the first, and perhaps not quite so stationary. I then pointed the meteoroscope to an estimated position, somewhere between the two meteors, and gave the altitude and azimuth readings. Immediately after I took with the meteoroscope the position of *Regulus*. I then mapped down on a piece of paper six neighbouring stars, *Regulus* included, together with the estimated position of the radiant point. By reference to Johnston's Star-map, allowance being made for the annual variations since the date of the map (1850), I obtained for the position of the point, R.A.$=148^\circ\ 59'$, Decl. $= +\ 22^\circ\ 47'$. The observation with the meteoroscope being reduced in the same manner as the other observations of meteors, gave for the azimuth from N. towards E., $83^\circ\ 44'$, and for altitude, $25^\circ\ 12'$; whence by calculation R.A.$=150^\circ\ 58'$, and Decl.$=\ +\ 23^\circ\ 36'$. This result does not agree with the other, owing perhaps in part to error in the noted time of the observation. As such an error would affect the determination of R.A. in greater degree than that of Decl., I propose to give double weight to the value of the R.A. derived from the map, and equal weights to the two values of the Declination. Thus, the concluded position of the Radiant Point will be, R.A.$=149^\circ\ 39'$, Decl.$=\ +\ 23^\circ\ 12'$.

Being chiefly occupied with taking observations of position and direction of flight, I did not note the lengths of course and the times they occupied, although, as it now appears to me, this class of observations is of great importance with respect to the theory of the phenomena. The following are the principal physical circumstances that I remarked. The meteors began to make their appearance at $11\frac{1}{4}^h$; from $11\frac{1}{2}^h$ to 13^h the number continually increased, attaining a maximum probably about $13\frac{1}{4}^h$ for the northern half of the heavens. At 14^h I noted that the number had much declined, and at $14\frac{1}{4}^h$ when I left off observing, the rate might be about one each minute. Almost all of them had trains, the majority of which lasted from one to three seconds, a few remaining much

longer. The magnitudes ranged for the most part between that of *Venus* at her brightest and a star of the second magnitude, those of inferior brightness being the exception. The apparent directions were remarkably conformable to the hypothesis of radiation from a fixed point of the heavens, that is, of a fixed direction relative to the Earth supposed to have no motion of translation. In these three particulars this November set of meteors presented a marked contrast to those I have frequently observed at the August period, in which a large majority were extremely small, trains were the exception rather than the rule, and a large number deviated considerably from an exact law of radiation. Another circumstance which also I had not noticed at the August period, was a blue or green appearance of several of the trains, with heads of a ruddy colour. Some few of the heads also were thought to be blue. I remarked that during a great part of the time over which the observations extended, there was a kind of *glow* throughout the heavens, a phenomenon which I was familiar with by my previous experience at the Cambridge Observatory, and which my assistants also noticed, and were accustomed to call "Auroral Light." It was, however, never accompanied by auroral streamers. Mr. Glaisher has informed me that the magnets at Greenwich were remarkably quiet during the night of November 13.

Cambridge, January 4, 1867.

On the Spectra of the Meteors of Nov. 13–14, 1866. By John Browning, Esq.

To view the shower I chose the Observatory of Mr. H. Barnes, at Upper Holloway. The situation was good, the Observatory being built on high ground, and so placed that the Radiant Point rose in the contrary direction to the lights of London.

I devoted my attention exclusively to attempting to obtain the spectra of as many meteors as possible.

After catching a few spectra in different directions, I at length decided on keeping the direct-vision prism pointed a little to the west of *Leo Major*, with the axis of the prism parallel to the horizon. The spectra which I saw were those of meteors which started from the Radiant Point and passed through the belt of *Orion*. Of course the number of meteors which came into my field was comparatively limited, but the whole of them travelled in a direction parallel to the axis of the prism, a condition essential in the observation of the spectra.

From the rapid flight of the meteors rendering the spectra

very difficult to catch, I cannot pretend to speak with confidence of the appearance of the spectra shown by the prism, but I saw a great difference between the spectra. I believe that I saw spectra of the following kinds :—

A. Continuous spectra, or those in which the whole of the colours of the solar spectrum were visible, excepting the violet rays.

B. Spectra in which the yellow greatly preponderated; but which in every other respect resembled those above described.

C. Spectra of almost purely homogeneous yellow light, but with a faint continuous spectrum, that is, a faint trace of red on one side and green on the opposite side of the yellow portion of the spectrum.

D. Spectra of purely homogeneous green light, of this kind I only saw two.

I observed through the prism spectra of several trains. The light which was mostly blue, green, or steel grey, generally appeared homogeneous; but this may have arisen from the light having been too faint to produce a visible spectrum. Stars below the 2nd or 3rd mag., although visible through the prism, fail from this cause to give spectra in which blue and red are perceptible.

It will probably be remarked that I have not spoken of having observed any lines in the spectra. All the nuclei seemed to give continuous spectra which contained the whole of the colours of the spectrum; what I should term the tails, not the trains, of the nuclei, presented the appearances I have described. In every instance I remarked that orange-yellow appeared to preponderate over the other colours in the continuous spectra. When a prism only is used it seems to me impossible that any sharply defined lines should be shown. Still, from differences in the colours of spectra, some information may, I think, be obtained. As is well known, chemists and mineralogists infer the presence of certain elements in the substance under analysis, from the colour communicated by the substance to the blowpipe flame. Thus: if the flame become yellow they suspect the presence of sodium; red, strontium; green, barium or thallium; lavender, potassium. The prism will do more than this, it will show if the flame contains even a faint trace of any other colour, while without the prism the faint colour would be completely masked by the colour which predominates. From the difficulty of catching meteors within such a narrow space, I fear it will be found impossible to use a prism provided with a slit formed by a pair of knife edges so as to define any lines. But, I think it may be possible to use prism in connexion with a cylindrical lens. Such an arrange ment would be capable of showing well-defined lines, if th observed meteors contained any elements which would gi bright lines in an ordinary spectroscope.

I desire to express my great obligations to Mr. Alexander Herschel for the constant attention and invaluable assistance he has rendered me in my endeavours to pursue this investigation, on which he is known to have made such successful researches and added so much to our stock of information; indeed, but for Mr. Herschel's kindness, I should not have approached the subject.

On a Bright Meteor, Nov. 13–14, 1866.
By R. Hodgson, Esq.

After the meteoric shower had subsided, and only occasional trains appeared at intervals, I noticed at $3^h\ 6^m$ past midnight, or Nov. 13 $15^h\ 6^m$ G.M.T., a brilliant train, which burst with a very bright nucleus larger than *Jupiter*, so close to the house that it appeared within a few yards; its direction was from *Leo* towards the two stars in the tail of *Ursa Major*, and as it was not seen by the observers at Greenwich (seven miles due south), I am inclined to believe the outburst was within half-a-mile.

Chingford, Essex,
15 *Nov.* 1866.

Accounts of the Meteoric Shower of 1866, Nov. 13–14, have also been received from Mr. E. J. Lowe, observing at the Highfield House Observatory, and from Mr. Talmage, at Mr. Barclay's Observatory, Leyton, Essex.

On the Solar Eclipse of 1868, *August* 17.
By Major J. E. Tennant, R.A.

(*In a Letter to Mr. Stone.*)

Will you allow me through you to draw attention of the Council to the total eclipse of August 17, 1868?

I presume no observers from Europe will feel disposed to incur the voyage for the sight, but there will be no lack in India if the matter be taken in time, and the Indian Government can be induced to give facilities, if they will give no greater aid.

I have just placed the Centre Line, as given in the *Nautical Almanac*, on the map. I find that entering India on the west, near Kolapoor in the south of the Bombay Presidency, it passes by the confluence of the Kistna and Bheeura to Gopalpoor and Masulipatam on the eastern coast. In the Bay of Bengal it would seem to pass among the small islands lying on the north

of the Andaman group, and then passes through the southern portion of the Tenasserim Province.

On the Malabar coast and in Tenasserim there will not be much chance, I fear, of any observations. In the Tenasserim Province there will be a good deal of the rainy monsoon to pass through; on the Bombay coast it will be nearly over. I fancy, too, that the Andamans will not have very fine weather, but on the Madras coast and to the east of the Ghauts there will be everywhere almost certainly fine weather.

Mr. Pogson will doubtless do his part, but Masulipatam is readily accessible from both Calcutta and Madras by steamer, and is itself a port at which they call. It will be quite in the power of the Government, if so disposed, to collect at that place a corps of practised observers; and even if they will not do this, I have little doubt that, if their officers are permitted to go, there will be some (possibly enough) observers who would form a party for the occasion. Probably the Council will not think that it would be too much to ask that the Government should, by organising an observing party or two, give the business that element of discipline and unity of action which volunteer observers, collected from various parts of a large country, will almost necessarily want.

The season is favourable, being a time when the officers of the Indian Survey will be in quarters, and when they could be best spared. I know nothing of what may be my own station in India, but I much fear that I have but little chance of sharing in what is done. I will, however, take in hand the accurate computation of the Central Line and limit of Totality, and hope before my return to India I shall be in a position to circulate to possible observers what may guide their arrangements.

22 Henrietta Street, Cavendish Square,
Jan. 2nd, 1866.

Astronomical Postulate regarding the Verification of Janamajaya's Eclipse. By G. Peacock, Esq. F.R.G.S.

In the ninth volume of *Bengal Asiatic Researches*, published in Calcutta in 1809, at page 447, the following passage occurs, being the purport of the inscription on a brass-plate, one of three dug up, fastened together by a ring on which is the representation of a seal, bearing the figure of a boar with a sun and crescent. It is as follows:—

"Janamajaya, son of Pariskshita, a monarch reigning at Hartinapur, made a progress to the south, and to other quarters, for the purpose of reducing all countries under his domination, and performed a sacrifice for the destruction of serpents, in presence of the God, or Idol, Harrihara, at the confluence of the rivers Tungabhadra and Harida, at the time of

a partial eclipse of the Sun, which fell on a Sunday, in the month of Chaitra, when the Sun was entering the northern hemisphere, the Moon being in the Nakshatra Aswini."

Having completed the sacrifice, the king bestowed gold and land on certain Brahmans of Gautama-grána, whose names and designations are recited at full length, with the description of the lands granted.

The words of the text are "Chaitramása crishna," or the dark half of the month, and a Chaitra answers to the month between 15th March and 15th April, the dark half would seem to imply the time of the *new* Moon for that month, at which time *only* could an Eclipse of the *Sun* happen, and this would be late in March or early in April,—the dark half of the Moon being then turned towards the Earth, and within the limits of 17° in the lunar nodes, as a Solar Eclipse only can happen when the Moon's latitude, as observed geometrically, is less than the term of the semidiameters of the Sun and Moon combined, because the course of the Moon, in its path, being oblique to that of the Sun, makes an angle with it of nearly 5° 35′; an Eclipse of the Moon can only happen at the time of full Moon, when the Earth is in a right line between it and the Sun.

Now, in examining into the date of the Eclipse named in our text, and working out the Dominical Letter and Epact, according to the tables in the Prayer-Book and those given by Fergusson, it would seem to have been that named in Fergusson's *Astronomy*, at page 217, in Struyck's Catalogue of Eclipses, as having been observed at Constantinople on the 3d April, A.D. 889. The record on the third plate states that the Moon was in "Nakshatra Aswini," which answers to the zodiacal sign *Aries*, and which would also coincide with the month "Chaitra," or between the 15th March and 15th April; as the sign Aswini, or the Horse's head, comprised a portion, or period of the zodiac, little over thirteen days, the dark shadow of the Moon, and therefore the Sun would be in Aswini on the 22d March, coincident, or nearly so, with the sign *Aries*, and would quit Aswini on the 4th April to enter Bharani. I have calculated all the other eclipses of the Sun, happening between the 22d and 31st March, from the year 1261 down to 1699,—twelve in number, or during the period of Aswini's path; but not one of these happened on a Sunday; and no Solar Eclipse took place in Aswini at any period (except the 3d April) answering to Sunday. There was a Solar Eclipse observed at Rome on the 1st April, A.D. 238, and one on the 2d April, 1307, observed at Ferrara, but neither of these fell on a *Sunday*: therefore, I am of opinion that the one named in the text must have occurred on the 3d April, A.D. 889.

Learcrop, 15th November, 1866.

Occultations of Stars by the Moon and Phenomena of Jupiter's Satellites, observed at the Royal Observatory, Greenwich, from May 1866 *to December* 1866. By G. B. Airy, Esq., Astronomer Royal.

Occultations of Stars by the Moon.

Day of Observation.		Phenomena.	Moon's Limb.	Mean Solar Time.	Observer.
1866.				h m s	
Sept. 28		75 Tauri, reapp.	Dark	12 41 26·4	E.
		Bradley 619, reapp.	Dark	13 29 29·0	E.
	(*a*)	Aldebaran, reapp.	Dark	16 31 30·0	J. C.
Nov. 16		67 Aquarii, disapp.	Dark	5 16 51·9	E.
20		ξ Arietis, disapp.	Dark	6 57 56·8	E.
27		*o* Leonis, disapp.	Bright	11 12 44·4	K.
		o Leonis, reapp.	Dark	12 9 29·0	K.

(*a*) The star did not come out with full brilliancy instantaneously; it was about $0^s·3$ before it fully reappeared. This, however, might have been due to a passing cloud.

Phenomena of Jupiter's Satellites.

Day of Obs.	Satellite.		Phenomenon.	Mean Solar Time.	Observer.
1866.				h m s	
May 23	III.	(*a*)	Occult. reapp. last contact	13 35 53·2	D.
July 9	I.		Eclipse, disappearance	10 56 4·3	P.
10	II.		Transit, ingress, last contact	10 34 44·5	C.
	I.		Transit, egress, bisection	10 35 59·3	C.
	I.		,, ,, last contact	10 36 59·1	C.
	II.		,, ,, first contact	13 23 3·4	C.
	II.		,, ,, bisection	13 25 18·1	C.
	II.		,, ,, last contact	13 28 2·6	C.
19	II.	(*b*)	Occult. reapp. bisection	10 7 59·2	J.C.
–	II.		,, ,, last contact	10 10 28·8	J.C.
Aug. 9	I.		Transit, ingress, bisection	9 40 54·0	E.
	IV.	(*c*)	Eclipse, reappearance	10 25 1·8	E.
	I.		Transit, egress, bisection	12 0 16·1	E.
16	I.		Transit, ingress, first contact	11 24 5·9	H.C.
	I.		,, ,, bisection	11 26 35·5	H.C.
18	II.		Transit, ingress, bisection	11 10 53·4	E.

Day of Obs.	Satellite.	Phenomenon.	Mean Solar Time.	Observer.
1866.			h m s	
Sept. 17	I.	(*d*) Transit, egress, bisection	9 52 43·2	J.C.
19	II.	(*d*) Transit, ingress, first contact	9 56 32·1	P.
	II.	,, ,, bisection	9 58 46·7	P.
24	I.	(*d*) Transit, ingress, bisection	9 23 24·7	E.
25	I.	(*e*) Occult. disapp. last contact	6 42 46·7	J.C.
Oct. 16	II.	Eclipse, reappearance	6 35 7·7	K.
31	III.	Transit, ingress, first contact	6 13 4·7	K.
	III.	,, ,, last contact	6 16 34·1	K.
Nov. 11	III.	(*f*) Eclipse, disappearance	5 25 34·3	S.

(*a*) Very unsatisfactory; doubtful to two or three minutes.

(*b*) The sky hazy; *Jupiter* a confused patch of light.

(*c*) The observation accurate within a few seconds; the N.A. time of reappearance is nearly ten minutes later.

(*d*) Very unsatisfactory; the planet badly defined.

(*e*) The observation uncertain to two or three minutes; the image of the planet very faint and ill-defined.

(*f*) Very uncertain; the planet low and very faint, and the satellite scarcely visible.

The initials S., D., E., C., J. C., K., P., and H. C., are those of Mr. Stone, Mr. Dunkin, Mr. Ellis, Mr. Criswick, Mr. Carpenter, Mr. Kerschner, Mr. Plummer, and Mr. H. Carpenter.

The following Errata must be corrected in the Observations of Phenomena printed it the *Monthly Notices*, vol. xxvi. No. 8, page 288:—

Line 1, *for* $13^h\ 34^m\ 30^s{\cdot}7$ *read* $12^h\ 34^m\ 40^s{\cdot}5$.

Line 4, *for* $12^h\ 41^m\ 41^s{\cdot}9$ *read* $12^h\ 42^m\ 41^s{\cdot}9$; and *dele* the word "bisection."

Occultations of Stars by the Moon. By C. G. Talmage, Esq.

1866, November 14.

Occultation of 9 Aquarii.

		h m s		
Disappearance	=	5 8 56·15	G.M.T.;	Time exact, very clear, Moon's dark limb well defined.
Reappearance	=	5 46 20·00	,,	Moon's limb boiling violently.

1866, November 20.

Occultation of ξ Arietis.

		h m s		
Disappearance	=	6 58 7·50	G.M.T.;	Exact; definition excellent.
Reappearance	=	7 58 48·52	,,	Good.

1866, November 27.

Occultation of o Leonis.

Disappearance	= $11^{h}\ 12^{m}\ 58^{s}{\cdot}60$ G.M.T.;	Definition good; power 70.
Reappearance	= 12 9 39·29 ,,	Dark limb very visible and well defined; power 40.

Mr. Barclay's Observatory,
Leyton.

Observations of Total Eclipse of the Moon, 1866, *September* 24.
By John Tebbutt, jun., Esq.

I forward my observations of the total eclipse of the Moon which occurred on the 24th–25th ultimo. Owing to the ill-defined character of the Earth's shadow it was impossible to observe the different phases with accuracy. The following are the results:—

		d h m s	
Beginning of total phase ...	... Sept.	24 11 22 2	Windsor M.T.
End of total phase ...	... ,,	12 58 33	,,
Last contact with the shadow	... ,,	13 58 9	,,

The Moon was of a bright copper hue throughout the total phase, and was distinct enough to admit of both limbs being observed with the transit instrument. The resulting Right Ascension, compared with the *Nautical Almanac*, gives $10^{h}\ 3^{m}\ 15^{s}{\cdot}8$ as the longitude of the Observatory East of Greenwich. At the middle of the eclipse the north-west portion of the disk was remarkably bright, the *Via Lactea* was now beautifully distinct. Eighteen minutes before the end of the total phase the eastern limb began to grow very sensibly brighter. By far the most accurate observation on the occasion was that of an occultation of a star of the 7th magnitude near the northern limb during the totality. The star maintained its full brightness up to the time of disappearance, which occurred instantaneously at $11^{h}\ 31^{m}\ 7^{s}{\cdot}5$ Windsor mean time. I have observed many occultations of stars at the Moon's dark limb, but do not remember having seen one in which the disappearance was so remarkably sudden. The reappearance, unfortunately, was not observed. The sky was beautifully clear during the early period of the total phase, but after midnight a dense fog came on which partially obscured the Moon. The end of the eclipse was observed through thin clouds, which came rapidly from the south.

The following corrections should be made in my communi-

cations published in the *Notices of the Royal Astronomical Society*:—

Vol. XXV.,

p. 43, 5th line from bottom,	*for*	21st August	*read*	19th August.
43, 4th	,,	19th August	,,	21st August.
194, 8th	,,	$* - 2' 48''\cdot 1$	,,	$* + 2' 48''\cdot 1$.
195, 9th line from top,		$\Delta\lambda = -90''\cdot 4$	,,	$\Delta\lambda = -90''\cdot 0$.
258, 14th	,,	Feb. 22^d 7^h 55^m 9^s	,,	Feb. 22^d 8^h 15^m 9^s.

Windsor, New South Wales,
October 22nd, 1866.

On the Correction of the Secondary Spectrum of Object-Glasses. By W. Wray, Esq.

Having been engaged for many years in experiments relating to the residual spectra of refractors, I beg leave to say a few words on the subject, and to announce that I have completely succeeded in removing all trace of chromatic aberration from object-glasses, upon a system extremely simple, and by no means expensive. The results which have been well, and for a long time tested, appear to warrant me, at once, to make the matter known to the Members of the Society. It is not my intention, at present, to occupy an undue share of attention, nor to enter into many details; these I would reserve for a more extensive paper, if the matter possess sufficient interest.

The subject of the irrationality of spectra is one which has engaged my investigation since 1855. It occurred to me in that year, after an examination of the quantities of residual colour given by first-class object-glasses, that there might be found such a difference of irrationality between two independent sets of glasses, as to allow of a compensation by opposite effects. In this expectation I was, however, disappointed, for I found that within the range of materials to be readily obtained in practice, the difference of irrationality between any given two pairs was comparatively inconsiderable. One thing, however, I learnt by this, what appears as a large residue of secondary colour in many fine refractors, is not really so, but a mixture of *primary* and *secondary;* consequently, the results, as obtained from two object-glasses of the same aperture, focus, and power, by different makers, and made from different materials, are often vitiated by their not being in a fair condition for rigorous comparison.

Having, however, subsequently freed such glasses from all trace of *primary* chromatic aberration, I found, as is well known, that the higher the dispersive ratio the greater the residual spectrum; but the comparative difference in even

extreme cases was, as I have just remarked, considerably less than what I had been led to expect. Still there was a difference, and that difference would lead one, so far as the construction of the ordinary object-glass is concerned, to condemn the use of high dispersive ratios, such as exist between crown and heavy flint glasses.

In working out this matter, I have tried a very great number of different kinds of glass,—both flint and crown,—flint glasses more particularly, formed from various metallic oxides and with densities ranging from 2·833 to the density 5·49 of Dr. Faraday's boro-silicate of lead; my object being to form a triple or quadruple combination, in which one of the *convexes* should have a very high dispersive power, and correct the irrationality of the other lenses. I regret, however, to say, that by glasses alone the subject remains to me still nearly hopeless; for the difference of irrationality between any given crown and the flint of density 2·833, and between the same crown and Dr. Faraday's glass, is not sufficient to allow of a destruction of the secondary spectrum, with anything like a reasonably shallow system of curves, even where four lenses are combined.

By means, however, of a judicious selection of flint and crown glass, and an extremely thin meniscus film of highly dispersive cement, there is no difficulty whatever, not only in completely destroying the irrationality, but even in inverting the spectrum at pleasure, the green light being, in the latter case, seen bounding the outer diffraction ring, *inside* focus.

Having made several glasses of from 4 to 7 inches aperture upon this plan, I can speak with confidence as to its success. Under very high powers I get a perfectly achromatic image of the Moon and planets, which are shown in a surprisingly sharp and clean manner on the black ground of the sky, reminding one of a first-class reflector, under its very best behaviour.

The intense blackness of the lunar shadows, under high powers, and the peculiar and variegated tints seen on the surface of the Moon are finely brought out; but, perhaps, the best comparison between the presence and absence of the secondary spectrum is made on *Jupiter*, as I have done with two glasses, each of 4 inches aperture, and nearly the same focus,—one, very fine, on the old plan,—the other perfectly achromatised. With a power of 200 or 250 the absence of chromatic confusion in the latter telescope had a striking effect on the definition of the belts and markings, and showed an image much more brilliant and pleasing than was given by the other glass. These glasses are now in the possession of E. C. Tufnel, Esq., Fellow of the Society.

For spectrometric analysis, I apprehend that the perfect achromatism of this arrangement may be found of some service. The Astronomer Royal having kindly undertaken to examine a large object-glass for me, I may conclude this notice by saying

that a 7-inch clear aperture of $8\frac{1}{2}$-feet focus, just finished, promises fairly to substantiate what I have represented.

1 Clifton Villas, Highgate Hill, N.,
12 *Dec.* 1866.

On the Telescopic Disks of Stars. By G. Knott, Esq.

At the Meetings of the Society in June and December last year the question of the relation between the size of the telescopic disks of stars and the aperture of the telescope attracted some little attention, and it was suggested as desirable that attempts should be made to measure the diameter of the spurious disk, or, in preference, that of the brighter part of the first ring.

Being in possession of a spherical crystal micrometer, which was mentioned by Mr. Dawes as well adapted for the purpose, I have, on several evenings during the past few months, employed it in the measurement of star disks; and although I have not yet succeeded in measuring the diameter of the first ring, I venture to bring the results I have obtained before the notice of the Society, in the hope that they may not be quite without interest.

The micrometer, which was formerly in the possession of Mr. Dawes, differs from that described by Dr. Pearson, in having no field lens; the whole of the magnifying power is, consequently, given by the sphere, and is invariable. The sphere has a diameter of rather more than four-tenths of an inch, and on my Alvan Clark refractor of $7\frac{1}{3}$ inches aperture and 110·6 inches focal length gives a magnifying power of 368. The aperture of the telescope was varied by cardboard diaphragms placed in front of the object-glass. I have for convenience arranged my results in a tabular form, and need only say in explanation that, with the single exception of the 2-inch measures of α *Coronæ Borealis*, the result in each case is the mean of six measures, which were generally fairly accordant.

Table of Observations

Date of Obs.	Star Observed.	Diameter of Disk, as measured with various Apertures.					
		7in·33	6in·00	4in·95	4in·00	3in·00	2in·00
		″	″	″	″	″	″
July 10	α Coronæ Bor.	0·833	..	1·172	..	1·748	2·324
Oct. 22	α Tauri	..	0·846	1·047	1·398	1·772	2·608
	Polaris	..	0·929	1·130	1·395	1·729	2·378
	α Orionis	..	0·852	1·214	1·683	2·162	2·932
Nov. 6	β Cygni A	..	0·995	..	1·414	1·865	..
	β Cygni B	..	0·691	..	1·051	1·425	..
	Polaris	..	0·919	1·246	1·542	1·802	2·480

Date of Obs.	Star Observed.	Diameter of Disk, as measured with various Apertures.					
		7in·33	6in·00	4in·95	4in·00	3in·00	2in·00
	α Orionis	″ ..	″ 0·888	″ 1·142	″ 1·604	″ 2·038	″ 2·728
Nov. 20	α Lyræ	0·731	0·807	0·991	1·284	1·829	2·435
	β Cygni A	0·666	0·839	..	1·162	..	..
	β Cygni B	0·586	0·643	..	0·948	..	..
28	α Tauri	0·760	0·956	1·144	1·535	1·763	2·564
	α Orionis	0·583	0·786	0·990	1·384	1·909	2·608
	β Orionis	0·583	0·753	..	1·402	..	2·658

Remarks on the Observations.

July 10. Definition good, but sky rather hazy. In addition to the measures recorded in the table I made one set of α *Coronæ*, with 3in·7 aperture, the resulting diameter of the disk being 1″·470.

October 22. Bright moonlight. Moon near the full. Definition good. I was struck with the fine definition of α *Orionis*. The disk was round and sharp, but the rings bright and troublesome.

November 6. The observations of β *Cygni* and its attendant were a little uncertain, as the stars were unsteady In the case of α *Orionis* I again found the rings bright and troublesome.

November 20. Bright moonlight and a frosty air. The definition of α *Lyræ* was good, but when the measures of β *Cygni* were made, vision had deteriorated.

November 28. Air still and definition good. A white frost. The measures of α and β *Orionis* were made as the Moon was rising. Moon about last quarter.

I shall close with a few general remarks. While I am not inclined to attach any value to the measures, as giving ***absolute results***, I think that they are interesting ***differentially*** as showing a marked and pretty regular increase in the diameter of the apparent disk, as the aperture of the telescope is diminished,— thus agreeing with theory. A few months ago, in reference to the subject of the diameter of star disks, Mr. Baxendell remarked to me, that "it would be interesting to compare the results from stars of different colours." This is certainly a very interesting subject for inquiry; but my own observations have as yet been too few to enable me to draw any trustworthy inferences from them bearing on the point. In conclusion, I will only express the hope that this imperfect paper may serve to direct the attention of some more competent observer to a delicate but most interesting branch of research.

Woodcroft Observatory, Cuckfield,
December 13, 1866.

Some further Remarks on the Use of the Eye-piece Prism in Measuring the Position-Angles of Double Stars. By the Rev. W. R. Dawes.

In my paper on the influence of the angle of position of double stars on the results of micrometrical measures (see *Monthly Notices*, June 1866), I adverted to an objection to the use of the prism suggested by Mr. Otto Struve, grounded on the possibility of errors of a different kind being introduced by it, and that in every case it might injure the quality of the telescopic images; and I understood him to say that this was the reason why astronomers in general had not adopted the use of the prism.

In a letter I have lately received from him, he says that his "*principal* objection to the exclusive use of the prism for observing double stars always in an apparently vertical line, consisted in the impossibility of ascertaining or avoiding by that means the so-called constant correction and its dependence on the distance."

With respect to this objection, I need only say, that my great object in the use of the prism was not either to ascertain or avoid such correction, but to obtain a *uniformity* in the measurements which I believe to be unattainable when they are made in all positions without any such precaution against the effect of obliquity. I also found in my own case that the error in the observed angle was far less when the stars were placed in an apparently vertical line than in any other position; and the small remaining error was not only *discovered*, but also entirely and easily *corrected*, by the simple process of measuring artificial stars made in pieces of cardboard, which admitted of the measurement of the very same objects in different positions by placing the pieces of cardboard on their different sides accurately cut. By this method also the *amount* of the error was presently found; and both that amount and the question of its dependence on the distance between the stars may be easily settled, by those observers who might not consider it worth while to pursue the observations on the artificial objects to the extent necessary for *destroying* the liability to error. This however I considered to be a result of sufficient importance to induce me to continue such observations until I found there was no remaining tendency to place the wires on one side of a vertical line rather than on the other; and for some years I occasionally had recourse to the same expedient, to maintain as far as possible a freedom from constant error in the measurements obtained in a vertical position.

Hopefield Observatory, Haddenham, Bucks,
1866, Dec. 13.

P.S. — It may be proper to add, that the use of the prism

was not recommended by me in *all* cases; but only in those where the obliquity was such that a slight and not inconvenient inclination of the head was insufficient to bring the stars into an apparently vertical position.

Measures of the Binary Star ζ Herculis.
By the Rev. W. R. Dawes.

The small companion of *ζ Herculis* having emerged from its recent conjunction (which appears to have occurred in 1862 or 1863), I have succeeded in obtaining some micrometrical measures of it; of which I beg the Society's acceptance, as they may possess some interest with those who may have procured observations of the same object. I first heard that the small star had again appeared, by a letter from Mr. Alvan Clark, who saw it perfectly separated from the large one with a fine 7-inch object-glass of his own manufacture in the autumn of 1865. But his letter found me laid by with severe illness; the effects of which, combined with the extremely unfavourable season, prevented my attempting measures of the star till last September. I was then surprised at the ease with which it was seen; and the only difficulty in obtaining good measures arose from the unsteadiness of the images.

The following were obtained at three different epochs:—

1866. Sept. 5	P = 235°·32	Obs. 2	Wt. 7	D = 1″± est.	Obs. 1	Wt. 3
14	235·97	7	32	1″± est.	1	2
17	234·27	5	33	0·800	4	13

Mean Result.

1866·70	P = 235°·14	Obs. 14	Wt. 72	D = 0″·856	Obs. 6	Wt. 18

1866. Oct. 16	P = 232°·94	Obs. 5	Wt. 33	D = 0″·827	Obs. 4	Wt. 13
31	226·86	7	52	0·830	4	28

Mean Result.

1866·81	P = 229°·22	Obs. 12	Wt. 85	D = 0″·829	Obs. 8	Wt. 41

1866. Dec. 30	P = 225°·26	Obs. 7	Wt. 51	D = 0″·974	Obs. 6	Wt. 39
31	224·30	3	12	1·017	4	12

Mean Result.

1866·99	P = 225°·08	Obs. 10	Wt. 63	D = 0″·984	Obs. 8	Wt. 51

The set taken on Dec. 30 was obtained ***exactly at noon***, the sky being quite unclouded. The smaller star was well seen, and the measures might have been got without any difficulty if the images had been usually as quiet as they were sometimes. The interval between the disks of A and B was about equal to one diameter of B. There was no light around the disk of A.

The set taken the next day was got at about 2^h P.M.; but though the image was occasionally pretty distinct, its unsteadiness was very annoying.

Mr. Otto Struve has recently sent me his measures of this highly interesting object on two nights in last autumn; the results of which are as follows:—

1866 Sept. 28	$P = 229^\circ.0$	$D = 0''.92$
29	223.5	0.97
Mean Result 1866·74	$P = 226^\circ.25$	$D = 0''.945$

Mr. Struve says that he found it an object of the utmost difficulty; that on some nights he was quite unable to see the small star; and that he was surprised at my having been able to obtain any measures of it.

Hopefield Observatory, Haddenham, Bucks,
1867, ***January 9th.***

Comparison of Sun-spot Observations by Schwabe with those made at Kew during 1866.

(***Communicated by Messrs. De la Rue, Stewart, and Loewy.***)

Months.	Dessau. No. of New Groups obsd.	Numbers of the Groups.		Days of observation.	Days without sun-spots.	Kew Observatory. No. of New Groups obsd.	Numbers of the Groups.		Days of observation.	Days without sun-spots.
Jan.	5	No. 1 to	5	30	0	7	No. 725 to	731	11	0
Feb.	7	6	12	27	1	5	732	736	12	0
Mar.	6	13	18	26	0	5	737	741	13	0
Apr.	5	19	23	28	0	5	742	746	16	0
May	3	24	26	27	4	4	747	750	23	5
June	6	27	32	30	2	4	751	754	13	1
July	1	33		31	8	3	755	757	13	2
Aug.	3	34	36	31	6	3	758	760	10	0
Sep.	2	37	38	30	14	2	761	762	14	7
Oct.	4	39	42	31	5	4	763	766	10	2
Nov.	2	43	44	30	13	3	767	769	14	5
Dec.	1	45		28	23	0			4	4
Year	45			349	76	45			153	26

Morning Illumination of Hippalus (Lunar Crater).

By W. R. Birt, Esq.

I should not have troubled the Society with this communication on a subject which is now, perhaps, of minor interest, instances of our general ignorance of minute lunar details being numbered by thousands, if not by tens of thousands, had not a communication on the same crater appeared in the *Monthly Notices*, vol. xx. p. 211. The observations forming the basis of that communication were made on March 2, 1860, with the Society's telescope, Sheepshanks No. 5, aperture $2\frac{3}{4}$ inches, power 150 (?) During a very casual glance at *Hippalus* on the evening of September 19, 1866, with the Royal Society's telescope of $4\frac{1}{4}$-inch aperture, power 230, I saw very distinctly the division into the two portions, rugged and smooth, spoken of in my former communication, and noticed what the smaller telescope *did not show*,—the rill δ on Beer and Mädler's Map, No. 56 of Mädler's Catalogue in Beer and Mädler's *Beiträge*, and No. 268 of Schmidt's Catalogue. This rill I noticed to be certainly coincident with the well-marked division between the rugged and smooth portions seen in 1860. Having obtained so striking a confirmation of the correctness of my former observations with a more powerful instrument which clearly revealed the nature of the separation on the floor of *Hippalus*, and which led me to regard it as a formation allied to the Plain of Dionysius (see *Reports of the British Association*, 1865, p. 304), I consulted Beer and Mädler's Map as to the delineation of this rill with a result by no means rare, viz. that in this as in numerous other instances their delineations are very faulty. The N.N.W. end of the rill takes its rise at a more northerly point, and also that the part of the rill which crosses *Hippalus* with the S.W. and W. parts of the wall enclose a much greater portion of the floor than shown by Beer and Mädler. The evening of October 19, 1866, being fine, and definition admirable, although clouds were frequently passing, I very carefully scrutinised *Hippalus* with this result:—My observations in 1860 were confirmed in every particular, except, perhaps, that with the larger instrument, the semi-elliptical and sinuous form of the wall came out with great precision, which, as seen in the smaller instrument, is described as nearly semicircular. The two very minute craters were distinctly seen, one very near, but on the E.N.E. side of the rill, the other on the opposite side at the S. extremity of the wall, also close to the rill. Neither of these are given by Beer and Mädler, but in the place of the more southern crater, close to the δ, a mountain is indicated on their Map. The crater on the E.N.E. I observed to be surrounded with a lucid, glowering appearance, and I have this indicated at the same place in a sketch made on March 5, 1860 (when the small instrument was used), as a bright spot, part of the

rill having been seen at the same time as a bright line. Clouds coming over prevented me from further examining *Hippalus* on the evening of October 19, 1866.

As on the four occasions alluded to above the observations so far confirm each other as to indicate that observations made with small instruments are deserving of attention, and that the smallest of the Society's astronomical telescopes may be used with advantage, I trust I may be allowed thus far to take up the time of the Meeting with a subject otherwise unimportant.

On the Obscuration of the Lunar Crater "Linné." By W. R. Birt, Esq.

The interesting phenomenon of a change in the appearance of the crater "Linné" was communicated to me by Herr Schmidt, the Director of the Observatory at Athens, an extract from whose letter is as follows :—

"*Athènes, Nov.* 17, 1866.

"Monsieur,—Depuis quelque tems je trouve qu'un cratère de la lune situé dans le plaine du *Mare Serenitatis*, n'est plus visible. Cette cratère nommé par Mädler 'Linné' se trouve dans la quatrième Section de Lohrmann sous le signe A. Je connais ce cratère depuis 1841, et même en pleine lune il n'était pas difficile de l'apercevoir; 1866 en Octobre et Novembre, à l'époque du maximum de son apparence, c'est à dire un jour avait le lever du soleil à son horizon, cette profonde cratère, dont le diamètre est 5·6 milles Anglais, était parfaitement disparu; seulement un lueur, un petite nuage blanchâtre se présentait au lieu de Linné. Auriez-vous bien la bonté de faire quelques observations sur cette localité.

"J. F. JULIUS SCHMIDT."

The earliest information respecting the crater I received from Mr. Buckingham, who favoured me with a copy of a photograph taken by him on November 18, 1866. On this photograph the place of "Linné" is visible, but faint. I have during the last lunation received records of observations from the following gentlemen: Doctors Mann and Tietjen, and Messrs. Talmage, Webb, Slack, Grover, and Jones. On the 13th, when the terminator passed over the east boundary of the *Mare Serenitatis*, the place of "Linné" was seen by Messrs. Webb and Talmage; Mr. Webb's aperture 9¼-inch silvered glass reflector, and Mr. Talmage's 10-inch refractor of Mr. Barclay at Leyton. Mr. Webb described the appearance as an ill-defined whitishness on the site of "Linné." Mr. Talmage recorded "a dark circular cloud." The exact position of these appearances was carefully ascertained afterwards and found to agree with the place of "Linné." Doctor Mann and

I at Leyton were prevented by a thin veil of cirrus seeing the "cloud" recorded by Mr. Talmage. With smaller apertures both Mr. Grover and I were unable to detect the slightest trace of "Linné," while the small crater "Linné B" of Beer and Mädler, and also Bessel, were very distinct *with the shadows within them*. On the following evening, December 14, observations were made by Messrs. Webb, Slack, Grover, and Birt. A white spot was seen in the position of "Linné." Mr. Webb described it as the most conspicuous object on the E. half of the *Mare Serenitatis*. Mr. Slack saw a whitish spot not remarkably bright, but could see no trace of a crater. Mr. Grover recorded "a tolerably defined roundish whitish speck," but he could not see the interior or margin of the crater, and "in this respect the spot showed very different from Bessel and other craters which were well seen." My own observations perfectly agree with the above. I estimated the light at 3°. On the 15th the spot was brighter, and I obtained the measures recorded below. On the 16th Messrs. Jones and Grover described the appearance as a white spot not over bright.

On the 20th Professor Foërster and Dr. Tietjen observed "Linné" with the Berlin Refractor. The following is the translation of the letter which I received from Dr. Tietjen, dated Berlin 21, December 1866:

"On viewing the Moon last night about 13^h M.T. Berlin with our refractor, in order to convince ourselves of the disappearance of the crater 'Linné,' Professor Foërster and I perceived that crater very distinctly. If, therefore, an obscuration has taken place on which certainly no doubt can exist, as it is affirmed by so competent an authority as Herr Schmidt of Athens, it has evidently now ceased."

Although Dr. Tietjen considers that the obscuration *has ceased* it does not appear that either he or Professor Foërster *has seen into* the crater.

The whole of the observations are so accordant among themselves, and the measures appended so clearly indicate the white spot to be larger than the crater "Linné," as to leave no doubt that a change of some kind has taken place; and this conclusion appears to be supported by previous records which are here appended :—

Date.	Authority.	Brightness. °
1653	Riccioli	
1788, Nov. 5	Schröter	0·5
1823, May 28	Lohrmann	7·0 +
1831, Dec. 12, 13	Beer and Mädler	6·0
1858, Feb. 22	De la Rue	5·0
1865, Oct. 4	,,	5·0
	Rutherford	6·0
1866, Nov. 18	Buckingham	2·0

The last four determinations of brightness are from photographs. There is some uncertainty in determining this element on the prints. Schröter, in plate ix. of his *Selenotopographische Fragmente*, gives a large dark spot in the place of "Linné;" and the Rev. T. W. Webb informs me that "Linné" is not to be found on Russell's globe or maps, 1797, from which it may be inferred that the crater has previously been obscured.

The following measures were made during the last lunation:—

Date. 1866.	Dionysius. "	Linné. "	Mag.	Miles.	Brightness. °
Dec. 15	14·70	11·61	0·79	10·9	4
18	14·13	7·07	0·50	6·9	5·5
19	13·95	7·32	0·52	7·2	5
21	13·32	6·75	0·51	7·0	4

The numbers in column 4 headed "Mag." are obtained by dividing the measures of "Linné" by the measures of the standard spot "Dionysius." The normal magnitude of "Linné" is 0·40 ("Dionysius" being unity) as determined by two independent methods. The numbers in column 5 headed "Miles" are not absolute, but only relative as compared with "Dionysius," by means of the numbers in column 4. "Dionysius" according to Lohrmann, is 13·8 English miles, and "Linné" according to Schmidt, 5·6 English miles in diameter. During the lunation no trace of the *crater* has been seen.

Minor Planet (91).

Elements calculated by Dr. Tietjen, *Ast. Nach.* No. 1621, from Leipzig observation of 10 Nov. and Berlin observations of Nov. 17, 27, and Dec. 8:—

1866, Dec. 8·0, Berlin M.T.

$$\begin{aligned}
M &= 329^\circ\ 2'\ 6''\!\cdot 5 \\
\pi &= 71\ 38\ 51\cdot 2 \\
\Omega &= 11\ \ 1\ 48\cdot 7 \\
\iota &= 2\ \ 7\ 58\cdot 0 \\
\phi &= 6\ 36\ 58\cdot 0 \\
\mu &= 848''\!\cdot 428 \\
\text{Log } a &= 0\cdot 414265
\end{aligned}$$

(π, Ω, ι: Mean Equinox, 1866·0.)

The elements represent the longitudes accurately; for the latitudes they give

C − O $+0''\!\cdot 9$ $-0''\!\cdot 7$ $-1''\!\cdot 1$ $+0''\!\cdot 8$.

ERRATA

in the *Monthly Notice* for December.

In the observation at foot of page 33, and the second and third observations on page 34, the order of the reference stars should in each be reversed.

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J. H. C.

MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. XXVII. *February* 8, 1867. No. 4.

THE Annual General Meeting of the Society:

Rev. CHARLES PRITCHARD, President, in the Chair.

Francis Cranmer Penrose, Esq., Wimbledon;
John Morgan, Esq., Glasgow;
Francis Bowen, Esq., Trinity College, Cambridge; and
James Carpenter, Esq., Royal Observatory, Greenwich,

were balloted for and duly elected Fellows of the Society.

Report of the Council to the Forty-seventh Annual General Meeting of the Society.

Progress and present state of the Society:—

	Compounders.	Annual Contributors.	Non-residents.	Patroness, and Honorary.	Total Fellows.	Associates.	Grand Total.
December 31, 1865	167	272	22	4	465	46	511
Since elected ...	12	23	...	...	...	4	...
Deceased	−7	−5	−8	...	...	−3	...
Name withdrawn	...	−1	...	...	...	...	...
Expelled	...	−7	...	...	...	...	...
Resigned	...	−3	...	...	...	...	...
Removals	+1	−1	...	...	...	...	...
Dec. 31, 1866 ...	173	278	14	4	469	47	516

Mr. Whitbread's Account as Treasurer of the Royal Astronomical Society, from January 1 to December 31, 1866:—

RECEIPTS.

	£ s. d.	£ s. d.
Balance of last year's account		307 17 2
By Dividend on £2500 Consols	33 18 6	
By ditto on £5000 New 3 per Cents	73 15 0	
By ditto on £2600 Consols ...	38 7 0	
By ditto on £5000 New 3 per Cents	73 15 0	
		219 15 6
On account of arrears of contributions ...	144 18 0	
129 annual contributions	271 19 0	
34 admission-fees	71 8 0	
23 first contributions	42 0 0	
	530 5 0	
12 compositions	249 18 0	
		780 3 0
Sale of publications		72 0 0
		£1379 15 8

EXPENDITURE.

	£ s. d.	£ s. d.
alaries :—		
Editor of Publications	60 0 0	
Assistant Secretary	100 0 0	
Commission on Collecting	30 2 0	
		190 2 0
Taxes :—		
Land and Assessed	6 11 0	
Income	1 13 4	
Poor Rate	8 2 6	
Other Parish Rates	9 11 8	
		25 18 6
Repairs :—		
Beard and Morrison, painters ...	43 9 4	
Bunnington, carpenter	13 14 0	
Taylor, floorcloth, &c.	7 16 0	
		64 19 4
Bills : —		
Strangeways and Co., printers ...	219 11 10	
Rumfitt, bookbinder	13 19 4	
Basire, engraver	39 12 6	
Pearson, wood-engraver	2 10 0	
Roberson, cleaning paintings	4 15 0	
Cooke and Sons, Equatoreal Stand ...	55 17 6	
Annual Dinner (deficiency)	11 11 6	
Insurance	10 0 6	
		357 18 2
Miscellaneous items :—		
Reduction of Sir W. Herschel's observations	50 0 0	
Books and parcels	5 10 7	
Postages	41 5 1	
House expenses	27 8 6	
Expenses of evening meetings ...	13 13 0	
Waiters attending meetings	3 17 0	
Coals and wood	12 0 0	
Gas	8 0 4	
Repairs	2 14 6	
Sundries	18 19 5	
		183 8 5
		822 6 5
Lee Fund	6 0 0	
Turnor Fund	5 7 8	
Mrs. Jackson's annuity, 1 year ...	8 17 0	
		20 4 8
Total payments		842 11 1
Investments :—		
Purchase of £300 Consols, 87⅛ ...	261 15 0	
Ditto 200 89¾ ...	179 15 0	
		441 10 0
Balance at Banker's	98 4 7	
Less Pearson's cheque unpaid ...	2 10 0	
		95 14 7
		£1379 15 8

Audited and found correct, this twenty-ninth day of January, eighteen hundred and sixty-seven,

H. Perigal, jun., *Auditor.*

sets and Present Property of the Society, January 1,

,—

	£ s. d.	£ s. d.
ance at Banker's		95 14 7
Contributions of 5 years' standing	21 0 0	
,, 4 ,, ...	8 8 0	
l ,, 3 ,, ...	132 6 0	
1 ,, 2 ,, ...	113 8 0	
27 ,, 1 ,, ...	155 8 0	
74 ,,		
1 admission-fee, &c., and subscription for 1866	5 5 0	435 15 0
Due for Publications		2 10 6

£5000 New 3 Per Cents (including Mrs. Jackson's Gift, £300).

£2800 Consols, including the Lee Fund (£100) and Turnor Fund (£500).

Unsold Publications of the Society.

Various astronomical instruments, books, prints, &c.

Balance of Turnor Fund (included in Treasurer's Account) 101 3 9

Stock of volumes of the *Memoirs* :—

Vol.	Total.	Vol.	Total.	Vol.	Total.
I. Part 1	15	XI.	191	XXII.	187
I. Part 2	56	XII.	198	XXIII.	187
II. Part 1	73	XIII.	211	XXIV.	193
II. Part 2	37	XIV.	400	XXV.	203
III. Part 1	90	XV.	179	XXVI.	211
III. Part 2	100	XVI.	204	XXVII.	470
IV. Part 1	109	XVII.	201	XXVIII.	427
IV. Part 2	121	XVIII.	183	XXIX.	454
V.	135	XIX.	194	XXX.	208
VI.	156	XX.	185	XXXI.	18[illegible]
VII.	179	XXI. Part 1	316	XXXII.	21[illegible]
VIII.	165	XXI. Part 2	100	XXXIII.	2[illegible]
IX.	169	XXI. (together).	97	XXXIV.	[illegible]
X.	181				

The instruments belonging to the Society are as follows:—

The *Harrison* clock,
The *Owen* portable circle,
The *Beaufoy* circle,
The *Beaufoy* transit,
The *Herschelian* 7-foot telescope,
The *Greig* universal instrument,
The *Smeaton* equatoreal,
The *Cavendish* apparatus,
The 7-foot Gregorian telescope (late Mr. Shearman's),
The Variation transit (late Mr. Shearman's),
The Universal quadrant by Abraham Sharp,
The *Fuller* theodolite,
The Standard scale,
The *Beaufoy* clock, No. 1,
The *Beaufoy* clock, No. 2,
The *Wollaston* telescope,
The *Lee* circle,
The *Sharpe* reflecting circle,
The *Brisbane* circle.

The *Sheepshanks'* collection of instruments, viz.,—

1. 30-inch transit, by Simms, with level and two iron stands.

2. 6-inch transit theodolite, with circles divided on silver; reading microscopes, both for altitude and azimuth; cross and siding levels; magnetic needle; plumbline; portable clamping foot and tripod stand.

3. $4\frac{6}{10}$ achromatic telescope, about 5 feet 6 inches focal length; finder, rack motion; double-image micrometer; object-glass micrometer; two other micrometers; one terrestrial and ten astronomical eyepieces, applied by means of two adapters.

4. $3\frac{1}{4}$-inch achromatic telescope, with equatoreal stand; double-image micrometer; one terrestrial and three astronomical eyepieces.

5. $2\frac{1}{4}$-inch achromatic telescope, with stand; one terrestrial and three astronomical eyepieces.

6. $2\frac{1}{4}$ achromatic telescope, about 30 inches focus; one terrestrial and four astronomical eyepieces.

7. 2-foot navy telescope.

8. 45-inch transit instrument, with iron stand, and also Y's for fixing to stone piers; two axis levels.

9. Repeating theodolite, by Ertel, with folding tripod stand.

10. 8-inch pillar-sextant, divided on platinum, with counterpoise stand and horizon roof.

11. Portable zenith instrument, with detached micrometer and eyepiece.

12. 18-inch Borda's repeating circle, by Troughton.

13. 8-inch vertical repeating circle, with diagonal telescope, by Troughton and Simms.

14. A set of surveying instruments, consisting of a 12-inch theodolite for horizontal angles only, with extra pair of parallel plates; tripod staff; in which the telescope tube is packed; repeating table; level collimator, with micrometer eyepiece; and Troughton's levelling staff.

15. Level collimator, plain diaphragm.

16. 10-inch reflecting circle, by Troughton, with counterpoise stand; artificial horizon, with metallic roof; two tripod stands, one with table for artificial horizon

17. Hassler's reflecting circle, by Troughton, with counterpoise stand.

18. 6-inch reflecting circle, by Troughton, with two counterpoise stands, one with artificial horizon.

19. 5-inch reflecting circle, by Lenoir.

20. Reflecting circle, by Jecker, of Paris.

21. Box sextant and 3-inch plane artificial horizon.

22. Prismatic compass.

23. Mountain barometer.

24. Prismatic compass.

25. 5-inch compass.

26. Dipping needle.

27. Intensity needle.

28. Ditto ditto.

29. Box of magnetic apparatus.

30. Hassler's reflecting circle, with artificial horizon roof.

31. Box sextant and $2\frac{1}{2}$-inch glass plane artificial horizon.

32. Plane speculum artificial horizon and stand.

33. $2\frac{1}{2}$-inch circular level horizon, by Dollond.

34. Artificial horizon roof and trough.

35. Set of drawing instruments, consisting of 6-inch circular protractor; common ditto; 2-foot plotting scale; two beam compasses and small T square.

36. A pentagraph.

37. A noddy.

38. A small Galilean telescope, with the object lens of rock-crystal.

39. Six levels, various.

40. 18-inch celestial globe.

41. Varley stand for telescope.

42. Thermometer.

43. Telescope, with the object-glass of rock crystal.

These are now in the apartments of the Society, with the exception of the following, which are lent, during the pleasure of the Council, to the several parties under mentioned, viz.:—

The *Fuller* theodolite, to the Director of the Sydney Observatory.

The *Beaufoy* transit, to the Observatory, Kingston, Canada.

The *Sheepshanks* instrument,		No. 1, to Mr. Lassell.
Ditto	ditto	No. 2, to Mr. De La Rue.
Ditto	ditto	No. 4, to Rev. C. Lowndes.
Ditto	ditto	No. 5, to Mr. Birt.
Ditto	ditto	No. 6, to Rev. J. Cape.
Ditto	ditto	No. 8, to Rev. C. Pritchard.
Ditto	ditto	No. 9, to the Director of the Sydney Observatory.
Ditto	ditto	No. 10, to Admiral Bethune.
Ditto	ditto	No. 19, to Capt. John Jones.
Ditto	ditto	No. 41, to Rev. C. Pritchard.
Ditto	ditto	No. 43, to Mr. Huggins.

The 6-inch circular protractor, to Mr. Birt.

The Volume of the Memoirs

will contain:—

I. "Mean North Polar Distances of *Rigel*, *α Orionis*, *Sirius*, *and α Hydræ*, for Jan. 1 of each Year, derived from Observations with the Transit Circle, made at the Royal Observatory, Cape of Good Hope, in the Years 1856–63." By Sir Thomas Maclear, Director of the Royal Observatory, Cape of Good Hope.

II. "Geocentric Right Ascensions and North Polar Distances of Encke's Comet, derived from Observations made at the Royal Observatory, Cape of Good Hope." By Sir Thomas Maclear, Director of the Royal Observatory, Cape of Good Hope.

III. "A Synopsis of all Sir William Herschel's Micrometrical Measurements, and Estimated Positions and Distances of the Double Stars described by him, together with a Catalogue of those Stars in order of Right Ascension for the epoch 1880·0, as far as they are capable of identification." By Sir J. F. W. Herschel, Bart.

IV. "Catalogue of Micrometrical Measurements of Double Stars, comprising all the Measures obtained by him between the close of his Second Series (published in the *R. A. S. Memoirs*, vol. xix.) and the present time." By the Rev. W. R. Dawes.

The former and principal part of the Series contains Observations made to the end of the year 1854: to which is added an Appendix containing such as have been subsequently effected. The Catalogue itself is preceded by a description of the different Micrometers employed.

V. "A Series of Observations at Malta with the Four-foot Equatoreal, comprising Observations of *Neptune* and his Satellites; Observations of the Satellites of *Saturn;* Observations

of *Uranus* and his Satellites; Observations and Drawings of known Nebulæ; Cursory Observations of various Objects not Classified; and a Catalogue of New Nebulæ." By Mr. Lassell.

OBITUARY.

The Society has to regret the loss of the following Fellows and Associates:—

Fellows.—Dr. Anderson.
W. Bowers, Esq.
J. Breen, Esq.
J. Burman, Esq.
W. Coffin, Esq.
G. Dollond, Esq.
Col. Sir George Everest.
Walter Ewer, Esq.
W. Gravatt, Esq.
W. D. Haggard, Esq.
Rev. J. Hind (prematurely reported last year).
R. H. Kennedy, Esq.
Dr. Lee.
Capt. Norquoy.
Admiral Owen.
Capt. Ronald.
G. T. Sadler, Esq.
Capt. H. Scott.
Lieut.-Col. P. Stewart.
G. Webbe, Esq.
Dr. Whewell.

Associates.—M. H. Goldschmidt.
M. Hencke.

JAMES BREEN was born at Armagh, Ireland, July 5, 1826. He was the second son of the late Mr. Hugh Breen, Sen., who superintended the Lunar Reductions at the Royal Observatory, Greenwich. He was educated at the Grammar-school (attached to the Cathedral) of his native town, then under the direction of the Rev. James Groves, M.A, of Trinity College, Dublin. In the August of 1840 he was engaged at the Royal Observatory as a calculator, and continued there till August 1846, when he was appointed at the Cambridge Observatory, where he remained zealously occupied as an astronomical observer until his resignation at the end of the year 1858. During this period he published a book, *The Planetary Worlds*. After leaving Cambridge Mr. Breen went to Paris, where he resided a considerable time, frequenting the lecture-rooms of the University, and studying French literature. Here he was introduced, amongst others, to M. Goldschmidt, who afterwards kept up a correspondence with

him. In the midsummer of 1860 he proceeded from Paris into Spain, where, at Camuesa, in conjunction with Mr. Buckingham and Mr. Wray, of the Himalaya Expedition, he observed the great solar eclipse of July 18. After some stay in Switzerland he returned to London in 1861, and devoted himself entirely to literary pursuits, spending much of his time in the Reading Room of the British Museum, enlarging his already considerable knowledge of English, French, and German literature, and cultivating an acquaintance with other languages. He was a contributor from the first to the *Popular Science Review*, and supplied articles to other portions of the press, but mostly anonymously. He had written a greater portion of a book on the Stars, Clusters, and Nebulæ: Mr. Hardwicke, of Piccadilly, having undertaken its publication, two sheets were already printed, when the ravages of consumption, which had been long undermining his constitution, rendered further work impossible. Conscious to the last, and prepared for the death which he knew to be inevitable, he expired tranquilly at noon, on August 25, 1866, and was buried on the following Wednesday in his father's grave at Nunhead Cemetery.

The late Sir GEORGE EVEREST was a son of Tristram Everest, Esq., of Gwernvale, Brecon, where he was born on the 4th July, 1790. He early showed signs of his future eminence, having qualified himself at Woolwich for a commission before the age at which the law admitted of his holding a commission, and he was especially noted by Dr. Hutton (then Professor of Mathematics), who, in a letter to his father, predicted his arriving at distinction. Everest sailed for India as a Cadet, to join the Bengal Artillery in 1806; and after seven years of military duty, was sent to join a detachment of his regiment in Java. Here he attracted the attention of Sir Stamford Raffles, then British Governor of that island, who selected him to make a survey of it; on which he was occupied from 1814 to 1816. On Sir George's return to India he was employed in improving the navigation of some of the numerous streams into which the Ganges divides itself before entering the sea, and afterwards in establishing telegraphic communication between Calcutta and the Upper Provinces.

On the completion of this last duty he was permitted to join Colonel Lambton, the original Superintendent of the Trigonometrical Survey of India, whose Chief Assistant he had some time before been appointed; and he entered on the labours which will ever connect his name with researches on the Earth's figure. Employment in an unhealthy part of the country drove him to seek health at the Cape of Good Hope, where his leisure was employed in criticising the Arc of the Meridian measured in that colony by the Abbé de La Caille. The result of his investigations was embodied in a letter to Lieutenant-Colonel Lambton, which appeared in the first volume

of our *Memoirs*, and which eventually led to the revision and extension of the Arc by Sir Thomas Maclear and his assistants, in the course of which the criticism was mainly justified. Not long after his return to India in 1823, Everest succeeded, at Colonel Lambton's death, to the superintendence of the Trigonometrical Survey. His attention was at once devoted to the Great Indian Arc of the Meridian, which he completed to latitude 24° 7′, when he was again compelled to resort to a better climate to recruit his health. While in England, on this occasion, he was enabled, by the liberality of the Honourable Court of Directors of the East India Company, to publish an abstract of his labours, which bears the date of 1830. In that year, too, Sir George Everest returned to India, having made himself acquainted with the instruments and processes in use in the Ordnance Survey, and taking with him a set of Colonel Colby's compensated bars for base-line measurement, new standard bars, and a 34-inch theodolite, as well as two vertical circles, especially intended for use in the observation of differences of latitude. All of these, as well as a number of smaller instruments for his department, were furnished by the late Edward Troughton.

From this time the operations of the Indian Survey became of an accuracy which has not been exceeded anywhere. The opaque signals previously employed were replaced by Heliostats in the day, and Argand lamps at nights; and it thus became possible to pierce the dense atmosphere of India in the dry season, and avoid the comparatively unhealthy rains. In crossing the plains of Upper India, it became necessary to elevate these signals and the instruments and observers to a considerable height on masonry towers, both to overcome the curvature of the Earth, and to avoid the dense and irregularly refracting strata of the atmosphere at the surface of the heated Earth. The new material rendered a new training necessary for the subordinate members of the department; and at the time this was being imparted, Colonel Everest's labours were increased by his appointment as Surveyor-General of India, and the abolition, very shortly afterwards, of the offices of Deputy Surveyor-Generals at Madras and Bombay. It was the end of 1832 before all the delays consequent on these matters were over, and the new apparatus and system had been tried in measuring a base line near Calcutta. Then, after a suspension of seven years, the measurement of the Meridional Arc was resumed, and its extension to the Himalayas was the first result. The experience gained here showed that the new arrangements had introduced an accuracy previously unattainable, and Colonel Everest proceeded, with the sanction of the Court of Directors, to revise that portion of the Meridional Arc which had been measured by him previously to 1830, between the latitudes of 18° 3′ and 24° 7′, and which he now made of the same accuracy as the northern portion. The whole of these operations

were completed in 1841 by the measurement near Bedur of a base-line under the immediate superintendence of Colonel Everest's chief assistant (now Sir Andrew Scott Waugh). The methods employed, and the results attained, are so fully detailed in a work published in 1847, by order of the Court of Directors of the East India Company, that it would be superfluous to enter on them here. The labours, of which that work is the record, were recognised by the award, in 1848, to its author by this Society of a Testimonial, to be considered as equivalent to a Medal, an honour which was shared with Colonel Everest by some of the most eminent of our Fellows. Sir George Everest's last publication on this subject was a letter to Professor Stokes in 1859, in which he made known some corrections to the numerical results contained in his book of 1847, arising from errors in the Logarithmic Tables employed, but he sat on the Council of the Royal Geographical Society up to his death, and at one time on that of the Royal Society.

Such, then, is a recapitulation of Sir George Everest's labours; but, in a case where services so eminent have been rendered to our especial science, we may be permitted to sketch slightly some of the points which distinguished our deceased fellow. Educated at a time when hardly any one in England was acquainted with the works of foreign mathematicians, and going at an early age to a distant land, Sir George Everest, in the intervals of a busy and practical life, nevertheless acquired a familiarity with the writings and methods of foreign geodesists, and appreciated them so much that he adopted their formulæ, verifying and extending them so as to prevent the accumulation of error in operations of an unprecedented magnitude, and he employed the acquired calculus in estimating, soon after assuming charge of the Survey, the attraction of the Mahadeo or Gawilgurh range of hills, on the station of Takalkhera, showing that the two arcs of which it was the common point were capable, by probable values for the masses of the attracting range, of being rendered accordant with the general figure of the Earth. Perhaps the greatest practical improvement he made was in the system of observing horizontal angles and azimuths. In 1808 the instrument he was to use (a theodolite, by Cary) was injured by an accident, which visibly distorted the limb. Colonel Lambton (the then Superintendent of the Survey) had by immense labour restored it to something like its original shape, and in some measure eliminated the remaining errors by changes of the initial reading or zero. Colonel Everest was led to adopt the plan of making this change by equal aliquot parts of the space between two micrometers. So satisfactory was the result that, when he acquired Troughton's beautiful instrument, he was induced to continue the practice. It is still in use with modifications which experience has led to in the number of zero changes, and it is peculiar, it is thought, to Sir George's old department.

In geodesical operations we cannot afford to consider the circle of an instrument as having constant errors of graduations, the jars and strains to which it is subject in travelling render them to some extent new at each station, and these circles are exposed, as none need or should be in a permanent observatory, to unequal heatings and currents of air. The mode of changing zero (as it is termed in India), introduced by our late Fellow, grappled successfully with these difficulties; and it is to his clear perception of the advantages he had gained by it that his successors owe that the angles of their triangles and their azimuths are determined in the field with an accuracy which (as they think) is not surpassed in the best works of fixed observatories. In apportioning the residual error among the angles of his triangles, Colonel Everest was one of the first (if not the first) to recognise the existence of equations of condition (to be fulfilled by the true angles) other than the old one which made the sum of the angles of a triangle$=180+$ the spherical excess.

Throughout his career as an astronomer and geodesist Sir George Everest was careful to cultivate in himself and impress on his subordinates habits of the most rigorous exactness. He never neglected any precaution, however slight, which might improve his work; and while sparing no pains in observation, repudiated with characteristic energy the sentiments of a foreign *savant*, who declared that the fancied perfection of the repeating circle removed the necessity for well-conditioned triangles. So scrupulous was Sir George, that he would have nothing to do with researches which he did not think admitted of the accuracy he cultivated, lest the assistants whom he had trained with so much care and labour might lose their aptitude for his objects.

Sir George Everest was a Companion of the Bath, a Fellow of the Royal Society and of the Royal Geographical Society as well as of this, and a Member of the Royal Asiatic Society, and an Honorary Member of the Asiatic Society of Bengal. J. F. T.

WILLIAM GRAVATT was the son of Colonel Gravatt, of the Royal Engineers, and was born about the year 1807. Destined originally for the profession of a civil engineer he received some instruction from his father, and went through a course of practical mechanics in the factory of Messrs. Bryan Donkin and Co. He was afterwards appointed assistant at the works of the Thames Tunnel, and subsequently associated with the younger Brunel for many years on the Great Western and Bristol and Exeter railways. He was especially interested in the construction and working of Scheutz's calculating machine; and he privately circulated a specimen of its work, in the shape of a set of barometric tables calculated and stereoglyphed by the machine made by Messrs. Donkin for the office of the

Registrar General. He was also the inventor of a level which is known as the "Dumpy Level." He was a full member of the Institution of Civil Engineers, a Fellow of the Royal Society, and a foreign member of the Royal Academy of Sweden. His death took place, under painful circumstances, on the 30th of May, 1866. A draught of medicine, containing morphia, intended to be given in two doses, was, by an unfortunate mistake, administered to him in one, and he never awoke from the sleep which ensued : the circumstances of his death demanding an inquest, a verdict equivalent to one of accidental death was delivered.

John Lee was the eldest son of John Fiott, a merchant of London (a descendant of the old Burgundian house, Fiott of Dijon), by Harriett, daughter of William Lee, of Totteridge Park, Herts. He was born on the 28th of April, 1783, and entered St. John's College, Cambridge, where he graduated as fifth wrangler in 1806. The senior wrangler of the year being Lord Chief Baron Pollock, of the Exchequer. In due course he was elected to a Fellowship of his College, and having obtained a Travelling Scholarship, he availed himself of the opportunity to visit Greece, Egypt, and the Holy Land, and succeeded in amassing a very valuable collection of antiquities. which it was always the study of his after-life to increase. In 1815, he assumed the name of Lee, in lieu of his patronymic, by royal license, in compliance with the will of his maternal uncle, William Lee Antonie, of Colworth House, Beds. On the death of Sir George Lee, Bart., without issue, in 1827, the whole of the family property devolved upon Dr. Lee. Dr. Lee was a Fellow of the Royal, the Antiquarian, the Meteorlogical, and many other learned and scientific Societies. He was elected a Fellow of our Society in 1824. He was Treasurer of the Society from 1831 to 1840, and served the office of President in the years 1861 and 1862. The Society is indebted to him for the establishment of the Lee Fund for the relief of the widows and children of deceased Fellows, and for a valuable Astronomical Instrument, the Lee Circle.

In the year 1836 he presented to the Society the perpetual advowson of the living of Hartwell, and in the year 1844 he added to his former gift the vicarage of Stone, both valuable livings, now held by Fellows of the Society.

Dr. Lee was twice married, but had no issue. He died February 1866, at the age of eighty-three, and will be long lamented by his friends for his kind and amiable disposition, and by his tenantry and others to whom he had endeared himself by his uniform benevolence and attention to their wants and interests.

The most important astronomical work of Dr. Lee's life was the establishment, in 1831, of the Hartwell Observatory, which was provided with first-class instruments, and maintained for many years in a state of efficiency.

Many valuable observations were made there by the late lamented Admiral Smyth, and for several years Dr. Lee secured the services of Mr. Pogson. Mr. Pogson, whilst with Dr. Lee, was chiefly employed in continuance of his observations on Variable Stars. It was a matter of great regret to Dr. Lee that he could not see the publication of the "Variable Star Atlas," incorporating all these observations of Mr. Pogson,— a work which was interrupted by Mr. Pogson's appointment to the Directorship of the Madras Observatory.

With the exception of a few papers in the *Archæologia* and other scientific publications, Dr. Lee was not distinguished as an author; but the liberality with which he patronised objects in aid of public utility is fully exemplified in the following list of valuable works by the late Admiral W. H. Smyth, which were published at his sole expense:—

1. Descriptive Catalogue of a Cabinet of Roman Imperial large Brass Medals. 4to. Bedford, 1834.

2. Ædes Hartwellianæ: Notices of the Manor and Mansion of Hartwell. 4to. London, 1851. In this work will be found a description of the Observatory and Instruments, and Observations made there by Mr. James Epps and Admiral Smyth.

3. Addenda to Ædes Hartwellianæ. 4to. London, 1864.

4. The Cycle of Celestial Objects continued at the Hartwell Observatory to 1859. 4to. London, 1860. This work is commonly known as "Speculum Hartwellianum."

In the life of WILLIAM WHEWELL, we have a striking example of the way in which in this country a man of real intellectual power, and determination of character, may break through the trammels imposed by humble birth; he was born on May 24, 1794, at Lancaster, where his father was a house-carpenter; his intellectual strength appears to have come from the mother's side. He was educated first at a grammar-school of his native place, and afterwards at Heversham, whither he removed in order to be qualified for holding an exhibition to Trinity College, Cambridge, connected with that school. Having gained this exhibition, then worth about 50*l.* a-year, he commenced residence at Trinity as a sub-sizar in October 1812. He soon became known in the College as the most promising man of his year. He was elected in due course to a foundation sizarship and to a scholarship. In his second year he gained the Chancellor's medal for the best English poem on the subject of "Boadicea." In the mathematical tripos of 1816, he graduated as second wrangler, the first place being gained by Jacob of Caius College. The Smith's Prize examination gave the same result. He was elected Fellow of Trinity in the following year, and soon afterwards commenced lecturing on mathematics as assistant tutor. His first book was *An Elementary Treatise on Mechanics*, vol. i. *containing* [illegible] *and part of Dynamics*. This work was published in

1819, but does not appear to have been followed by an *ostensible* vol. ii. It was a work of great value, strikingly logical and accurate. It is considered by one of our most eminent living mathematicians to have been very far in advance of any then existing text-book in the clearness and correctness of the treatment of bodies in contact and in the precision with which the assumptions involved in the laws of motion and the composition of forces are stated and illustrated. This work was followed by no less than twelve separate treatises on mechanics and Newton. Whewell was an advocate for the substitution of algebraical methods and modern calculus for the purely geometrical methods of former times, believing that it was only by these analytical methods that we could obtain solutions of our great physical problems, but he strongly insisted upon the necessity of studying the geometrical methods as an aid to a right understanding of our algebra. His view on this point is clearly expressed in the preface to his edition of *Newton's Three First Sections*. "It is very desirable that the mathematical student, before he rushes forward to differentiate and integrate upon the slightest provocation, should employ some thoughts in understanding the construction and trustworthiness of the instrument which he is so familiarly to use."

He was ordained soon after taking his M.A. degree. He became Tutor in 1823, and continued to discharge all the duties of the office alone till 1833, when he associated with himself Mr. Perry, the present Bishop of Melbourne. He remained tutor till 1839. During all this time he took a most active share in College and University business; serving with the greatest readiness on syndicates and committees.

In 1821 he was elected a Fellow of the Royal Society, which in 1837 accorded to him a Royal Medal for his investigations on the subject of the Tides.

His researches on the Tides undoubtedly constituted his principal direct contribution to the advancement of Science. He contributed no less than fourteen papers, and one supplementary paper, on this subject to the Royal Society. These papers will be found scattered through the *Philosophical Transactions* from 1833 to 1850. They are all of a similar character. Whewell attempted, from a discussion of Tidal Observations, to deduce empirically the laws of the tides at particular ports, and to trace any connexions which might exist between the constants which he thus obtained. He compared his results with Bernoulli's theory, and clearly pointed out those points which the theory could offer some explanation of, and those points which it could not touch. His great merit, in these researches, appears to have been the large and comprehensive views he took of the subject, and the energy with which he obtained the aid of and organised a body of observers for the contemporaneous observation of tidal phenomena all over the world.

It may be mentioned, to show that Whewell had a taste for practical science, although his path through life did not lead him in this direction, that he volunteered to and did assist the present Astronomer Royal in the pendulum experiments for the determination of the mean density of the Earth, made in a mine at Dolcoath, in Cornwall, in 1826 and 1828. These experiments both terminated in an unsatisfactory manner; the observers in 1826 had their instruments injured through a fire, and in 1828 the water broke into the mine, and thus put a stop to their operations.

In 1828, Whewell was made Professor of Mineralogy in the University of Cambridge. To prepare himself for this chair he went to Germany, and studied for some time under Professor Mohs. He also availed himself of his friendship with Professor Sedgwick to accompany him on his geological expeditions. In 1832 Whewell resigned this chair, and was succeeded by Dr. Miller.

He was one of the founders of the Cambridge Philosophical Society, and one of the most active promoters of the British Association.

In 1837 he published his *magnum opus*, the *History of the Inductive Sciences*. In the composition of this work he sought and received the most valuable assistance from a number of men eminent in their respective departments. For range of knowledge, for depth and grasp of thought, for lucidity of style, the *History* has few rivals in modern times. The *Philosophy of the Inductive Sciences* was published in 1841. This work was not so popular as its predecessor.

In 1838 he accepted the Professorship of Moral Philosophy, and henceforth he was to a great extent lost to physical science. In Moral Philosophy he was an ardent advocate for the rejection of Paley's basis of moral obligation, and substitution of that of moral sense; and he succeeded at last in expelling Paley's *Moral Philosophy* from the University. He wrote a valuable text-book on Moral Philosophy for the use of the University.

In October 1841 he succeeded Dr. Wordsworth in the Mastership of Trinity. And nobly did he uphold the pre-eminence of that College in the University.

He was twice married; first, in 1841, to Miss Cordelia Marshall; secondly, in 1858, to Lady Affleck, a sister of Robert Leslie Ellis. After his marriage with Lady Affleck, much of that ruggedness of manner which made him repellent to some passed away, and he became popular in that University where he had always been respected and admired. Lady Affleck died in 1865, deeply regretted by all who knew her. Whewell met with the accident that led to his death on February 24, and died on March 6, 1866.

His works are so numerous that it is almost impossible to collect a correct list of all of them. The principal of them are included in the annexed list, but this is, doubtless, far from

complete. It would, however, be wrong to close this short notice of his life without specially mentioning his *Bridgewater Treatise*, one of the most popular books of modern times; his *Plurality of Worlds*, which perhaps, after all, however only proves how much may be said on a subject about which we know nothing; and his *Metaphysical Introductions* to the Encyclopedias. It may be mentioned, as a proof of the high position he had won in different branches of knowledge, that he was a correspondent of the French Academy, not in a mathematical section, but in a metaphysical section (Académie des Sciences Morales et Politiques, Section Philosophie). The extent of his knowledge was indeed wonderful, and generally accurate. Ancient History, Mediæval History, Botany, Geology, Mineralogy—all seemed to be alike to him. His *Architectural Notes on the German Churches, and Notes written during an Architectural Tour in Picardy and Normandy*, is still a standard book on ecclesiastical architecture.

The very universality of his knowledge has perhaps induced some to doubt his soundness; but this opinion, we believe, will not be justified by an examination of his works. He may not have been the first man of his age in any one branch of science, but he was in the foremost rank of many; and all he wrote is stamped with the logical clearness and precision of his own mind.

Whewell's works:—

An Elementary Treatise on Mechanics. Cambridge, 1819.

A Treatise on Dynamics. Cambridge, 1823.

An Introduction to Dynamics. Cambridge, 1832.

On the Free Motion of Points and on Universal Gravitation. Cambridge, 1832.

Analytical Statics. Cambridge, 1833.

An Elementary Treatise on Mechanics. Cambridge, 1833.

Bridgewater Treatise on Astronomy and General Physics. London, 1833.

Architectural Notes on German Churches &c. London, 1833.

Mechanical Euclid. Cambridge, 1837.

History of the Inductive Sciences, 3 vols. London, 1837–38.

Philosophy of the Inductive Sciences, 2 vols. London, 1840. Expanded into History of Scientific Ideas.

The Doctrine of Limits, with the Application &c. Cambridge, 1841.

The Mechanics of Engineering, &c. London, 1841.

Conic Sections, &c. London, 1849.

On the Philosophy of Discovery. London, 1860.

Novum Organum Renovatum.

The Elements of Morality, including Polity, 2 vols.
Lectures on the History of Moral Philosophy in England.
Lectures on Systematic Morality.
Indications of the Creator. (In answer to the "Vestiges of Creation.")

Translations:—

Göthe's Herman and Dorothea.
Auerbach's Professor's Wife.
Grotius' Rights of War and Peace.
Platonic Dialogues for English Readers, 3 vols.

Anonymously:

On the Plurality of Worlds.

In the *Philosophical Transactions*:—

A General Method of Calculating the Angles made by any Planes of Crystals, &c. 1825.
Researches on the Tides, series i. to xiv. 1833–50.

In the *Transactions of the Cambridge Society*:—

On the Position of the Apsides of Orbits of great eccentricity. 1821.
On Double Crystals of Fluor Spar. 1822.
On the Rotatory Motion of Bodies. 1827.
On the Angles made by Two Planes or Two Straight Lines, referred to Three Oblique Co-ordinates. 1827.
On the Classification of Crystalline combinations, and the Causes by which their laws of derivation may be investigated. 1828.
Reasons for the Selection of a Notation to designate the Planes of Crystals. 1828.
Mathematical Exposition of the Doctrines of Political Economy. 1829.
On Ricardo's Principles of Political Economy. 1833.
On the Nature of the Truth of the Laws of Motion. 1834.
On the Results of Observations made with a new Anemometer. 1837.
Demonstration that all Matter is heavy. 1840.
Are Cause and Effect Successive or Simultaneous? 1842.
On the Intrinsic Equation of a Curve, and its Application. 1849.
On the Fundamental Antithesis of Philosophy. 1849.
Mathematical Exposition of some Doctrines of Political Economy. 1851.
Of the Transformation of Hypotheses in the History of Science. 1851.

On Plato's Survey of the Sciences. 1856.
On Plato's Notion of Dialectic. 1856.
Of the Intellectual Powers according to Plato. 1856.
On the Platonic Theory of Ideas. 1858.

Besides the above, there are numerous important papers scattered through the *Reports of the British Association* and other scientific publications.

Hermann Goldschmidt, one of the most indefatigable and at the same time one of the most disinterested amateur observers of the present age, was born at Frankfort-on-the-Maine on the 17th of June, 1802. He came into the world with a weak body, and, in his early days, suffered such delicate health that all the tender care of his parents was required to nurture and sustain him. Destined originally for a commercial life, he spent some dozen years in his father's warehouse, devoting his leisure hours to the study of modern languages and the cultivation of the painter's art. To this latter he at length resolved to apply himself entirely, and to this end he repaired to Munich, where he studied under the celebrated masters Cornelius and Schnorr, settling in Paris to perfect his artistic studies in the year 1836, in which year he exhibited his first picture, "A Woman in Algerian Costume." This was followed by many others which appeared in succeeding years on the walls of the art-exhibitions, and Goldschmidt became eminent as an historical painter; one of his later works, "The Death of Romeo and Juliet," having been commanded by the Minister of State. But we must pass thus briefly over this portion of his history, for it is with the astronomer rather than with the artist that we are concerned.

Goldschmidt had passed the middle time of life when a mere accident first induced him to turn his attention to astronomy. It appears, from his own account, that he suffered much from depression of spirits, and that he resorted to all possible changes of occupation in order to dissipate his melancholy humour. Chance led him one day to the Sorbonne, where he heard a lecture by M. Le Verrier, in the course of which the learned professor explained an eclipse of the Moon that was to occur on the same evening—the 31st of March, 1847. The explanation aroused in him an enthusiastic admiration for astronomy, and he determined to apply himself zealously to the study of the science, of which he had hitherto possessed but vague notions. Towards the close of the year 1849 he procured a little telescope, of not more than 2-inches aperture, which he purchased with the proceeds of the sale of one of two copies he had made at Florence of a portrait of Galileo: he alludes to the acquirement of this instrument as the happiest event of his life.

Three years after, with the help of the Berlin Star-charts, and with either this little telescope, or one a very trifle larger which superseded it, he discovered his first small planet, named by Arago *Lutetia*, and which was detected on the 15th of November, 1852. Steadily pursuing this branch of observation, he year by year added to his discoveries; increasing his telescopic power to 2¾-inches aperture, he picked up his four succeeding asteroids, *Pomona*, *Atalanta*, *Harmonia*, and *Daphne*. With a still larger, but still comparatively insignificant instrument, one of 4-inches aperture, he found the remaining nine, *Nysa*, *Eugenia*, *Doris*, and *Pales* (these two were discovered on the same night), *Europa*, *Alexandra*, *Melete* (supposed at first to have been *Daphne*, but afterwards found to be an independent planet), *Danaë*, and *Panopea*, which last was found on the 15th of May, 1861. Thus, within a period of nine years fourteen planets were discovered; and when we consider the paucity of the observer's means and the harassing nature of the observations upon which each discovery depended, we cannot but regard such a labour and such a result as unprecedented in the history of observational astronomy. For Goldschmidt had none of the recognised appliances of an observatory; his observing-room was by turns his humble *atelier* on the sixth floor of a *café* in one of the most frequented streets of the Quartier Latin, and by turns the garret forming his sleeping apartment; his area of observation being limited to the regions of the sky which the windows of these chambers commanded.

Although these discoveries form the basis of Goldschmidt's fame as an astronomer, they do not comprise the whole of his labours; he was an assiduous observer of variable stars, stellar satellites, comets, and nebulæ; he also formed one of the band of observers who journeyed into Spain to witness the Solar Eclipse of July 1860. His labours, however, were almost entirely observational. His contributions to the literature of Astronomy consist chiefly of short notices of the results of his observations, or announcements of his discoveries. The longest of his papers is probably that on the abovementioned eclipse. During the later years of his life, when his failing sight compelled him to relinquish his telescopic work, he seems to have had a tendency to speculative astronomy: for a few months before his death he circulated a memoir on the favourite topic of speculation, the Physical Constitution of the Sun and the origin of Solar Spots. He appears to have applied his artistic powers to astronomical objects, for his memoir on the eclipse was accompanied with three paintings in oil; and in one of his letters to M. Le Verrier he mentions a series of studies in oil which he had made of Donati's Comet.

Although Goldschmidt was not a salaried observer, and derived no direct pecuniary advantage from his astronomical works,

his labours did not pass without recognition and encouragement. Eight times the Lalande Astronomical Prize was awarded to him by the Academy of Sciences; the Cross of the Legion of Honour was conferred upon him in 1857; an annual pension of 1500 francs was accorded to him in 1862. He received also the Gold Medal of this Society in the year 1861, and was elected an Associate in May 1866.

In his private life he was esteemed for the modesty of his demeanour and the amiability of his disposition. He died at Fontainbleau on the 30th of August, 1866. J. C.

PROCEEDINGS OF VARIOUS OBSERVATORIES.

Royal Observatory, Greenwich.

The work of the Royal Observatory, Greenwich, during the past year, has been of the usual character. The Moon has been observed at every possible opportunity, on the meridian with the Transit-Circle, and off the meridian with the Altazimuth. The observations are thus extended to feel certain inequalities of the greatest importance for the completion of the Lunar Theory. This completeness has given to the Greenwich Lunar Observations a value which belongs to those of no other Observatory. The work of re-observing all the stars in Bessel's *Fundamenta* has been very nearly completed, and it is intended to collect the results of the Star Observations made from 1861 to 1867 into a new Catalogue. The central cube of the Transit-Circle has been pierced, and a clear view of Collimator from Collimator, through the cube, has been thus obtained. The new collimators, by Simms, have been mounted and put into use. The Great Equatoreal has been employed in observations of occultations of stars by the Moon; in spectrum observations of T *Coronæ* and γ *Cassiopeiæ;* observations of the Crater *Linné*, and in observations of the Sun's photosphere.

An observation of the Sun's disk, made by the Astronomer Royal under very favourable circumstances, appears fully to support the description of the very minute granulation of the Sun's surface, described by Mr. Nasmyth as interlacing willow-leaves and by Mr. Stone as rice-grains, and totally different from the coarse mottling observed long since (consisting probably of unequal groupings of the granulation), and from the thatch-straws seen on the edges of the penumbræ of spots, so graphically described by Mr. Dawes.

In the last autumn an expedition was organised by Prof.

Bache, Director of the Coast Survey of the United States of America, for determining, by means of the Atlantic Telegraph, the difference of longitude between Heart's Content in Newfoundland and Foilhommerum in Valentia; and the Irish portion of the operations was intrusted to our Associate Dr. B. A. Gould. Dr. Gould selected for the site of his temporary observatory a place adjacent to the Telegraph Office at Foilhommerum. No official account of the observations and their result has yet been published; we understand, however, that three successful interchanges of signals were made on nights when sufficient star-observations were obtained, and that the results were satisfactory and accordant. Advantage was taken of the residence of Dr. Gould at Foilhommerum for determining its distance in longitude from the Royal Observatory, Greenwich; and it may serve to show the difficulty of conducting telegraphic longitude-operations in this climate, that, after a protracted sojourn of Dr. Gould in Valentia, only three nights' signals could be exchanged, of which one series was lost through want of clock error at Valentia, so that only two nights are available for use. By the kindness of Colonel Sir Henry James, Director of the Ordnance Survey, the several determinations of longitude in Valentia have all been referred geodetically to one point, namely, the Trigonometrical Station on Feagh Main; and it may be interesting to the Society to be made acquainted with the different results. The longitude of Feagh Main from the Royal Observatory of Greenwich is—

	m	s
By conveyance of chronometers from Greenwich to an Observatory on Feagh Main in 1844	41	23·23
By telegraphic communication with an Observatory at Knight's Town in 1862	41	23·37
By telegraphic communication with an Observatory at Foilhommerum in 1866	41	23·19

In the first and second of these operations the personal equations were determined; in the third they have not been determined. The geodetic reference is affected by the irregularities of attraction in a rather hilly island. We cannot however be far wrong in adopting $43^{m}\ 23^{s}{\cdot}28$ for the west longitude of Feagh Main.

The volume for 1865 has been nearly passed through the press, and the Reductions for 1866 are very nearly complete. The November Meteors were observed with great completeness. More than 8000 meteors were counted on the night of November 13, 1866. The times of maximum frequency were well determined, and the position of the radiant point fixed with great care. The galvanic operations have been carried on successfully, but without material alterations during the past year.

Radcliffe Observatory, Oxford.

The amount and nature of the work accomplished during the past year at the Radcliffe Observatory is of the same character as in the preceding year. A new list of stars for observation has, however, been compiled by Mr. Quirling, which includes all those stars of the British Association Catalogue which still require observing, together with others included between the seventh and the eighth magnitudes found in various Catalogues. The Sun has been observed whenever the state of the sky permitted it, and the Moon till the first observation after opposition in each lunation. *Mercury* has also been observed whenever it was visible on the meridian. The number of stars observed in 1866 is 980; while of the Sun 93 observations have been made; of the Moon 53; and of *Mercury* 28. The weather, however, during the year 1866 was exceptionally bad.

The heliometer was employed by Mr. Main for the observation of double stars as usual during such portions of the year as permitted it.

Five occultations of stars by the Moon were observed, and the time of commencement of the Solar Eclipse of October 8, 1866.

Advantage has been taken of the relative scantiness of the observing, for pushing forward the reduction of the observations, and with so much success that there are at present very few arrears. The transits are reduced to the end of 1866, excepting the corrections to mean places of unknown stars (that is, those not included in the B.A.C.); and the zenith distances are in a forward state. The astronomical reductions for 1865 are essentially complete. The meteorological reductions are however not so advanced, those for 1864 (the volume in the press) not being quite completed.

Advance has also been made in the printing of the Observations. The Astronomical Observations for 1864 are completely printed, together with an elaborate introduction; and a few copies have been sent to the chief observatories in England and Scotland.

The printing of the volume for 1865 is also commenced, and with a small difference of arrangement; namely, that the mean results of right ascensions and north polar distances are placed side by side in the same section, and the means of the observations are exhibited. This arrangement is considered by Mr. Main to be a very great improvement.

Of the extraordinary works of the past year, the most remarkable was the observation of the grand meteoric display of November 13, in which the Radcliffe Observatory took a full share. A great number of individual meteors were observed specifically, and the whole number counted was 3087.

It would appear therefore that this Observatory has been as successful as in former years, in carrying out fully the plan of observation and the amount of work which had been proposed by its Director. A volume of its astronomical and meteorological results is published annually, and the reduction and thorough discussion of the observations are at the present time in as forward a state as is desirable or possible. By its means all the stars in the Catalogue of the British Association which are visible in the Northern heavens will shortly have been reobserved, and, in consequence, a reliable place will be found for all stars which are individually of much value for comparison, in the various branches of astronomy; while, at the same time, this amount of work has been accomplished with the most rigorous regard to fundamental accuracy, and to the elimination of every source of constant error from the results. The meteorological observations, with their elaborate discussions, form a serious addition to the labours of the Observatory, though they probably add to its reputation; and their utility will perhaps be better recognised as years roll on, and especially when all observatories which are charged with the determination of the climates of their localities shall have been provided with self-recording apparatuses.

Cambridge Observatory.

The same course of observation as that of last year has been steadily pursued with a view to the completion of the Catalogue of Stars selected from the *Histoire Céleste*. A little more than 200 transit and 500 circle observations are still needed to make up the prescribed number.

A continuous effort has been made throughout the year to bring up the arrears in the reductions and to keep pace with the current observations. As a rule, hardly ever departed from, the entries from the note-books into the reduction-books for each night are made on the following morning: the means taken, and the correction for irregularity of pivots in the transit, and for runs in the circle, are applied. The Transit Instrument is reversed about once a month; and the remaining instrumental and clock corrections are calculated and applied as soon as possible afterwards, so that the apparent right ascensions are obtained up to the time of the last reversal. The level and collimation errors are obtained independently in each position of the axis, the reversal being used merely as a means of verification. The mean Right Ascensions for the beginning of each year are deduced to the end of 1865, and those for 1866 are in progress. The constants for obtaining the apparent from the mean places are computed for the selected list of Lalande's Stars, and for a few others. The mean

Right Ascensions from the separate observations of each star for the year are brought together as far as the end of 1863.

The apparent North Polar Distances are nearly completed to the end of 1866; the reductions to mean places are computed to the end of 1865, and are applied to the end of 1862. In order to get the reductions thus far advanced, it has been found necessary to employ an additional computer.

The carrying out of the contemplated series of meridian observations has left but little time for observations with the Northumberland Equatoreal. A Spectroscope intended to be used with this instrument has lately been constructed by Mr. Browning.

The Meteorological Observations have been carefully attended to. Their value is now increased by the erection of a Robinson's Anemometer.

Especial attention was given to the November Meteors. The courses of a large number have been deduced from the records of one or two observers; careful determinations of the position of the radiant point were made independently by Professor Challis and Professor Adams; and efforts were made by several other observers to count the total numbers in given intervals of time from the commencement of the display. A new Meteoroscope has been made by Mr. Simms, under Professor Adams' direction, according to a plan which, it is hoped, will secure greater rapidity, accuracy, and completeness in the observations.

The cost of this instrument, as well as of the Spectroscope and Anemometer, is defrayed by a grant from the Sheepshanks Fund.

Royal Observatory, Edinburgh.

Her Majesty's Government having supplied the necessary means, some essential repairs to instruments are being made. Books and transactions, received in many past years from foreign observatories and other scientific institutions, are being put in order. A little extension of the buildings of the Observatory, however, appears necessary; and the Astronomer has now proposed to a meeting of the Board of Visitors a plan for that purpose.

Of work performed, the next most constant and regular to the time-service by ball, and gun, and Jones's controlled clocks (of which six additional ones have been established within the year for the service of the new Post Office), is the reduction of meteorological observations for Scotland; ever pressing, not only from their representing fifty-five stations, but from having to be printed punctually every month and every quarter.

Meridian observations of stars with the Transit Instrument and Mural Circle have been carried on as usual.

Glasgow Observatory.

The operations at the Glasgow Observatory have not been distinguished by any feature of novelty during the past year. The Transit Circle continues to be employed in the steady prosecution of a series of star-observations, the objects chosen for this purpose generally falling below the sixth magnitude. The Ochtertyre Equatoreal has been mainly devoted to the measurement of a select number of the more interesting double stars contained in Struve's great Catalogue.

The operations for supplying the city of Glasgow with the advantages of true time continue to give unqualified satisfaction. A new wire has recently been erected chiefly with the view of being employed in transmitting Greenwich mean time to the shipping interests of the Clyde, and several clocks have been placed in connexion with it. The system now embraces eighteen clocks in the City and Port of Glasgow, which are maintained in perpetual control by a current of electricity directed from the normal mean time clock of the observatory.

A course of meteorological observations has been regularly prosecuted for some years past at the Glasgow Observatory, but except in the case of Osler's Anemometer the principle of continuous self-registration has not been employed. Professor Grant has reason to believe that this important defect will soon be remedied.

Report upon the Madras Observatory for the Official Year 1865, May 1st, to 1866 April 30th.

1. Notwithstanding the continued urgent want of European assistance, the proceedings of the Madras Observatory may be pronounced, upon the whole, more satisfactory than for several past years. The work accomplished has been throughout above the average amount in quantity, and when submitted to the test of publication will, it is hoped, be found equal in quality to any reasonable expectations on the part of the astronomical public. That great desideratum, however, publication, remains a matter of impossibility with the present insufficient establishment.

2. The construction of a convenient and suitable room, with a revolving dome, for the new Equatoreal, has at last been accomplished by Messrs. Leggett and Broomhall of Madras, in a most creditable and efficient style. The interior diameter of the dome is sixteen feet. Its rotation is effected by means of eight six-inch rollers or wheels, the axles of which are connected by a ring of hard wood, as in the much larger domes employed by Mr. Lassell of Liverpool, described in the twelfth volume of the *Memoirs* of the Royal Astronomical

Society. Notwithstanding the size and weight of the new dome, its motion is so smooth and perfect, that the pressure of a finger, or the single-handed force of a child of eight years of age, suffices to start it, while it stops dead wherever required. Two sliding shutters, easily opened, expose an observing slit three feet in aperture, and extending over nearly two-thirds of the dome, or from the horizon to about twenty-five degrees beyond the zenith. The new Equatoreal, by Messrs. Troughton and Simms of London, has been erected, and worthily sustains the high reputation of its makers. It is supported by a central iron pillar, on what is known as the German plan of mounting; and for steadiness, perfect equilibrium, and convenience in its mechanical details, it is all that the most fastidious could desire. Owing to the prevalence of bad weather since its very recent erection, no opportunity has yet occurred for finally adjusting or critically examining its eight-inch object-glass; but as this was duly tested and approved by the Astronomer Royal at Greenwich, before the instrument left England, it may be justly expected that it will prove as satisfactory in this important point as it has already been found in its mechanism. It is liberally equipped with all the usual appliances in the way of eye-pieces &c., and is also provided with an excellent parallel wire micrometer and a double-image micrometer of Mr. Airy's construction.

The former Equatoreal, by Messrs. Lerebours and Secretan, is in fair working order. Other extra-meridional instruments belonging to the Observatory are, a five-foot telescope, with a zodiacal portable stand, far from steady, and a good universal equatoreal stand, provided with three different telescopes, viz., two of three feet, and one of five feet focal length, the latter having been made up in Madras by Mr. F. Doderet, Mathematical Instrument-maker to the Public Works Department, with the object-glass (by Dollond) formerly used in the old and now discarded transit instrument. In the meridional department, the transit circle, also by Messrs. Troughton and Simms, continued to yield unexceptionable results from June 1862, the commencement of its career, until the end of March 1866, when symptoms of unsteadiness in the circle clamps suddenly appeared, which have given much trouble and anxiety during the last month of the official year. It is now undergoing repair in Mr. Doderet's hands, and will, it is confidently hoped, soon regain the former high character for permanence of adjustment and general excellence which it has so worthily maintained during the past four years. The old arrangement of shutters, most objectionable and inconvenient, opening in four sections, and never weather-proof, has been superseded by a single flap, twenty-three feet in length by two in breadth, counterpoised, and opening from within by means of ropes and pulleys in the usual manner. The mag-

netical and meteorological instruments are in fair working order, but those of the former class, in use since 1841, are by no means equal to those now constructed and used in European Observatories. The Anemograph, by Mr. Adie of London, is in satisfactory condition, and stood the test of two tolerably severe gales in 1865, without injury or failure.

3. The observations with the transit circle have been made throughout the year by the two head native assistants, as usual, and it may be remarked with pleasure, that their care and assiduity have secured results highly creditable to themselves, and of great value to science. The steady progress of the meridian observations will be best shown by the subjoined tabular statement of work done since the erection of the instrument in May 1862. The number of observations taken stands thus for the successive official years : —

Observations of	Moon.	Planets.	Stars.	Total.
1862–63	54	85	1723	1862
1863–64	70	77	2272	2419
1864–65	64	119	2409	2592
1865–66	55	91	2599	2745

We have, therefore, 9618 complete observations of Right Ascension and Polar distance, taken in three years and eleven months (1862–66), awaiting publication, averaging 2443 per year ; a large per-centage of which refers to stars in the Southern hemisphere, the positions of which have not been previously determined at any other Observatory. Reductions of standard stars and all instrumental corrections are kept rigorously up to date. Those of other objects are but little behind, being completed up to December 31st, 1863, and very nearly so up to October 1865.

The old Equatoreal has been employed chiefly in the construction and revision of the Atlas of Variable Stars in hand for several years past. Twenty-three observations have been taken of the five planets, *Isis*, *Ariadne*, *Hestia*, *Asia*, and *Sappho*, and numerous comparisons of variable stars have been made throughout the year. The periodical comets of Faye and Biela were sought for unsuccessfully, the former being much too faint for the telescope, and the latter having, doubtless for the same reason, eluded the pursuit of Astronomers generally, even when provided with instruments of the largest size. None of the equatoreal observations of planets or comets are yet ready for publication, but it is hoped that this year will be the last in which such will be the case.

4. Two small telescopic Variable Stars and one new Minor Planet have been discovered since the last report was written; of these *Z Virginis* had been previously mapped as an ordinary star of the tenth magnitude, but was found to have vanished

entirely in 1865. The other new variable X *Capricorni* was first seen and observed as a supposed new planet on July 26th, 1865. Neither the periodic time between two successive maxima, nor yet the range in regard to brilliancy of either of these objects, can yet be decided. Another new Planet was discovered on May 16th, 1866, in the constellation *Scorpio*, extremely faint, being but little brighter than a twelfth magnitude. The name selected for this 87th member of the asteroidal group is *Sylvia*, one suggested by Sir J. F. W. Herschel a few years back as suitable for a future new planet. From its slower apparent motion than that of most others when similarly situated, it has evidently a considerable mean distance from the Sun, but its orbital elements have yet to be calculated.

5. Magnetical and Meteorological Observations continue to be made three times daily as formerly; and the results of the latter are published in the *Fort Saint George Gazette*, and in one local newspaper. The arrears of the twenty years' series of hourly observations have been nearly worked up, and printing has been proceeded with so as to ensure publication at no distant period. The curves of hourly corrections for the barometer and dry and wet bulb thermometers will be of great service throughout India, as it is evident that they must be far more fairly applicable to tropical registers than those derived from observations made in the widely different climate of Europe. The early and remarkable heat of 1866 exceeded any previously recorded at Madras. The thermometer reached 110·6 in the shade on May 28th, the depression of the wet bulb being 35·8, and the per-centage of humidity so low as 16. A scheme for meteorological registrations is now under the consideration of Government which, if sanctioned, will greatly extend our knowledge of the climate of Southern India, and its important bearing upon the statistics of health, mortality, and the cultivation of the staple productions of the country.

6. The Rain Returns maintained with more or less regularity at upwards of 350 stations since 1852, under the control of the Revenue Board, are under discussion, and though many will doubtless have to be rejected as untrustworthy, sufficient will remain to furnish an interesting rain-map of the Presidency, showing the comparative influences of elevation above sea-level, and proximity to the coast, in a marked and highly instructive manner. New gauges of an improved and uniform pattern are about to be issued, and it is hoped that the increased accuracy of future returns will amply compensate for the additional outlay involved thereby.

7. The Madras mean time of the flash of the 8 P.M. gun has been carefully noted, and published as formerly, to facilitate the rating of chronometers in the Roads. It is intended as early as possible to carry out the long contemplated tele-

graphic discharge of the Fort and Mount guns, and the erection of three sympathetic electrical clocks, for the convenience of the public in various parts of Madras.

Durham Observatory.

At the Durham Observatory the principal observations have been those of the Minor Planets, especially of those most recently discovered. From observations made of the Planet *Io*, at Durham and elsewhere, at its first discovery, the observer, Mr. Dolman, calculated and published elements, corrected for the perturbations of *Jupiter* and *Saturn*. The ephemeris deduced from these elements has been found to agree sufficiently well with observations made at the present reappearance of the planet near opposition.

A few series of positions of planets at their first observations have been communicated to the *Astronomische Nachrichten*, and the rest will soon be published in the same manner.

The Equatoreal has lately been provided with a Spectroscope by Browning, London; but observations with it have not yet been commenced.

Liverpool Observatory.

The transfer of the instruments from the old Observatory on the Waterloo Dock Pier Head to the new Liverpool Observatory, Bidston, Birkenhead, is now nearly completed. Mr. Hartnup moved into the new house on the 22nd of December, but the transit room was not ready for the instrument until the 23rd of January; the chronometers were removed on the 25th of January; the new chronometer room is partly erected, and Messrs. Troughton and Simms are making preparations for the re-erection of the Equatoreal. The Barograph, the tube of which contains a column of mercury three inches in diameter, has been removed; the tube was let down to the bottom of the cistern, and the space between the cistern and tube calked, in this way it was successfully taken to the room prepared for it in the new building without any injury to the instrument. The telegraph wires are being laid for the transmission of galvanic currents from the Observatory to a seconds clock to be erected on the margin of the river opposite the Prince's landing-stage; a time-gun will be discharged by this clock, the movements of which will be controlled from the new Observatory.

In addition to the rating of chronometers, preparations are being made for testing ship's compasses, sextants, barometers, and thermometers; the conditions under which nautical instruments will be received and tested at the new Observatory have not yet been decided on..

Kew Observatory.

The Kew Photoheliograph has been employed in taking pictures of the Sun, whenever possible. In consequence of an arrangement made by the Kew observers with Hofrath Schwabe, of Dessau, the results at which both arrived with regard to numbers of new groups are now simultaneously published at the end of every year, in the *Monthly Notices.* Looking at these tables for 1865 and 1866, it was found that, although Hofrath Schwabe had, during these years, 656 days of observation against only 306 at Kew, still the total number of groups of Sun-spots observed at both places agrees precisely for each year. The differences observable in the numbers for each separate month are accounted for by the fact that, towards the end of a month, through unfavourable weather, new groups are very often observed later at Kew than by Hofrath Schwabe, and are hence distributed over different months by these respective observers. These two years' observations, therefore, show that the Kew method of observation has now reached a degree of reliability, as regards the ultimate results, which leaves nothing to be desired. In addition to the mere numbering of groups, the area of the spotted surface will in future be measured at Kew from day to day, by means of a convenient eyepiece attached to Mr. De La Rue's well-known instrument for determining the heliographic position of the spots; and the Kew observers hope thus to supply most valuable material for investigations of any nature connected with Sun-spots.

In a second paper, on Solar Physics, recently published, the authors, Messrs. De La Rue, Stewart, and Loewy, adduce evidence, chiefly derived from laborious measurements of the areas of Sun-spots observed by Carrington from 1853 to 1860, of the influence of planetary configurations on the behaviour of Sun-spots; and they arrive at the following results:—

1. That the behaviour of Sun-spots, which pass the same ecliptical longitude at the same or nearly the same time, is similar, and is therefore affected by some external influence; and that there is a period, or recurrence of the same behaviour, every nineteen or twenty months.

2. That in all these recurrences the phenomena always progress from left to right of the Earth, or in the direction of the motion with reference to the Earth, of the inferior planets; and that the equality in the synodical period of *Venus* (583 days) and the period of recurrence of similar behaviour in Sun-spots, points to *Venus* as the planet which apparently exerts the most predominating influence, although an influence of other planets, particularly *Jupiter*, is distinctly traceable.

3. That the nature of this planetary influence consists in a tendency to produce the maximum of Sun-spot activity on that

side of the Sun which is turned away from the influencing planet, and on the other hand, in a tendency to diminish the size of Sun-spots on that side which is turned towards it. Similarly, it would appear, with regard to *Venus*, that spots are nearest to the solar equator when the heliographical latitude of *Venus* is 0°, and are most distant from the solar equator when this planet attains its greatest heliographical latitude. This last point was brought prominently under the notice of the authors by a recent interesting circular by M. Chacornac, and is the subject of further investigation.

Messrs. De La Rue, Stewart, and Loewy, state that they are now actively engaged in preparing two new parts (iii. and iv.) of their "Researches" for publication in the course of the present year. One will contain the calculated positions of Sun-spots observed with the Kew Photoheliograph, and a deduction from those positions of the elements of rotation of the Sun. For the other paper the authors have proposed to themselves an investigation of planetary influence on Sun-spots, extending over the whole of Hofrath Schwabe's observations, with a view to separate more distinctly the action of each single planet, and thus of arriving, if possible, at an insight into the laws of planetary influence on solar activity.

Another problem, bearing on physical astronomy, which is to be worked out at Kew, under the direction of Mr. Stewart, is the proposed determination of the length of the seconds pendulum there. This work stands in connexion with the Indian pendulum experiments, for which the Kew Observatory forms the fundamental station. The preliminary experiments with Captain Kater's reversible pendulum, for careful determination of various necessary coefficients, have been completed during the past year, and will shortly be published.

Mr. De La Rue's Observatory.

At Mr. De La Rue's Observatory, at Cranford, besides the current work, special photographic observations of the Moon have been made and are still in progress, with the view of assisting in the investigation of an alleged change of visibility of the crater *Linné*, situated in the plain of the *Mare Serenitatis*. It is fair to assume that if any such change has taken place, the district immediately surrounding the crater will have been affected by it; and photography affords a ready means of determining this point. As to the minute crater itself, none but the stillest nights will be available for its delineation by photography; for, except on those rare occasions, the undulations of the atmosphere cause the projected image of the crater to dance over an area as great as that occupied on the plate by the crater itself. Up to the present time, a comparison of photographs taken in 1858 by Mr. De La Rue

and 1866 by Mr. Reynolds respectively has not elicited any apparent change in the vicinity of *Linné;* but further investigations are necessary before it can be positively affirmed, on the evidence of photography, that no such change of visibility has taken place.

The 13-inch photographic object-glass, ordered of the Messrs. Cooke, has not yet left their hands; but it is expected to be completed in the early part of the present year.

Mr. De La Rue has also ordered of Mr. George With, of Hereford, a 13-inch silvered glass speculum, with the view of comparing its performances with that of his own mirrors. Many of our Fellows are acquainted with Mr. With's productions, and may therefore feel interested in this competition between a 13-inch mirror of his manufacture and one of the same dimensions figured by Mr. De La Rue himself.

Mr. Huggins' Observatory.

At Mr. Huggins' Observatory, Upper Tulse Hill, observations on the spectra of the heavenly bodies have been continued.

Mr. Huggins has attempted the prismatic analysis of the light of other Nebulæ and Clusters. The light of many of these faint objects was found to be insufficient for a certain determination of the characters of their spectra. The examination of the following Nebulæ and Clusters was more satisfactory.

Nebulæ, the spectra of which consist of one or more bright lines:—

No. 385	76 M.	No. 386	193 H. I.
2343	97 M.		

Nebulæ, the spectra of which are apparently continuous:—

No. 342	100 H. I.	No. 1771	2 H. I.
352	17 H. V.	1823	205 H. I.
544	23 H. IV.	2008	163 H. I.
600	77 M.	2360	270 H. I.
1137	261 H. I.	2413	194 H. I.
1713	200 H. I.	2600	173 H. I.

The numbers in the above lists refer to Sir John Herschel's General Catalogue.

Lists of the Nebulæ and Clusters observed by Mr. Huggins during former years will be found in the Annual Reports of 1866 and 1865.*

* *Monthly Notices*, vol. xxv. p. 107, and vol. xxvi. pp. 144, 220.

The description "*continuous spectrum*," in these lists must not be understood to mean more than that, when the slit was made as narrow as the feeble light of the object permitted, the spectrum was not resolved into bright lines. The irregular brightness of many of the spectra classed as continuous suggests that probably either dark or bright lines are present.*

In August, 1864, Mr. Huggins recorded a peculiarity presented by the continuous spectra of the Great Nebula in *Andromeda* and its small but bright companion:—"The spectrum appears to end abruptly in the orange; and throughout, its length is not uniform, but is crossed either by lines of absorption or by bright lines." In May last the spectrum of the light of the central condensed portion of the cluster 13 M. *Herculis* was found to possess similar characters. The absence of the red, and of part of the orange rays, may be caused by absorbent vapours, through which the light has passed. The *apparently complete* want of light in this part of the spectrum, and the irregular appearance of the brighter parts of the spectrum, suggest, perhaps, that the light may have emanated from a gaseous source, and that the spectrum may consist of bright lines. The faintness of these continuous spectra has prevented the employment of a slit sufficiently narrow for the determination of their true character. The bright points of some clusters may, therefore, possibly not possess a physical constitution similar to the Sun, and the brighter of the separate stars.

For the purpose of ascertaining how far the arrangement of the nebulæ by the prism into two classes corresponds with the indications of their resolvability into bright points afforded by the telescope, Lord Oxmantown examined all the observations made at Parsonstown of 60 nebulæ which had been subjected to prismatic analysis by Mr. Huggins.

These Nebulæ may be arranged thus:—

	Continuous Spectrum.	Gaseous Spectrum.
Clusters	10	 0
Resolved, or resolved?	5	 0
Resolvable, or resolvable?	10	 6
Blue or green, no resolvability	0	 4
No resolvability seen	6	 5
	31	15
Not observed by Lord Rosse	10	4
	41	19

On May 16 Mr. Huggins received letters from Mr. Birmingham of Tuam, and Mr. Baxendell, announcing the ap-

* *Philosophical Transactions*, 1866, p. 381.

pearance of a bright star in *Corona Borealis*. The same evening, in conjunction with Dr. W. A. Miller, Mr. Huggins observed the remarkable compound spectrum of this star. An account of their observations of this star has appeared in the *Monthly Notices*.*

On September 15, Mr. Huggins was informed by Mr. Baxendell that T *Coronæ* had increased in brightness about two magnitudes from August 20. On several nights, up to October 8, the spectrum of T *Coronæ* was observed, but the determination of the characters of the spectrum was in some degree uncertain on account of the feeble light of the star. The bright lines, which were so conspicuous before the star reached its minimum were not *certainly* seen, and the part of the spectrum where they occur was not much, if in any degree, brighter than the adjoining parts.

The spectrum of γ *Cassiopeiæ* appears to be in some respects analogous to that of T *Coronæ*. In addition to the bright line near the boundary of the green and blue observed by Father Secchi, there is a line of equal brilliancy in the red, and some dark lines of absorption. The two bright lines are narrow and defined, but not very brilliant. Micrometrical measures of these bright lines show that they are doubtless coincident in position in the spectrum with Fraunhofer's C and F, and with two of the bright lines of luminous hydrogen. In these stars part of the light must be emitted by gas intensely heated, though not necessarily in a state of combustion. The nearly uniform light of γ *Cassiopeiæ* suggests that the luminous hydrogen in this star forms a normal part of its photosphere.

Observations have been made during the past year of the form and size of the bright particles which constitute the solar photosphere. Some of the results of this examination of the Sun's surface have appeared in the *Monthly Notices*.†

The spectra formed by the light from different parts of a solar spot have been examined. At present no certain modification of the solar spectrum has been detected.

Mr. Fletcher's Observatory.

Mr. Fletcher is still following out the work to which allusion is made in our last Report, viz., the reobservation of all the objects in Smyth's *Cycle*. The time that Mr. Fletcher is able to give to Astronomy is devoted exclusively to this work.

The Fellows will learn with regret that the Observatory of Downside College, near Bath, was completely destroyed by

* Vol. xxvi. pp. 275, 297. Also *Proceedings of the Royal Society*, vol. xv. p. 146.

† Vol. xxvi. p. 260.

fire on Sunday the 20th of January, 1867. This Observatory contained an equatoreal refractor of 14½ inches aperture, by Slater, a transit-circle, and other instruments, and had been completed only a few months since at an expense of nearly 3000*l.* Unfortunately neither the building nor its contents were insured; it is supposed that the disaster was caused by the overheating of a flue.

THE PROGRESS OF ASTRONOMY.

Southern Survey.

It will be a matter of great gratification to the Fellows of the Society, and to all interested in the advancement of our Science, to learn that the work of the great Southern Survey is in actual progress. The work has been undertaken by observers of acknowledged skill and energy, and the completion of this important work may now be confidently expected.

Asteroids.

During the past year six asteroids have been discovered.

(86)	Semele	by Tietjen on	1866 Jan.	4
(87)	Sylvia	Pogson	May	16
(88)	Thisbe	C. H. F. Peters	June	15
(89)	——	Stéphan	Aug.	6
(90)	Antiope	Luther	Oct.	1
(91)	——	Stéphan	Nov.	4

The number of the Asteroids already discovered is 91. This number is so great, that difficulty is experienced in obtaining Ephemerides sufficiently accurate for the identification and observation of these minute bodies on the meridian. This difficulty is a growing one. It will have to be met by combined systematic action, or many members of this system will ultimately be lost. The perturbations produced by *Jupiter* in the orbits of some of the Asteroids will, probably, ultimately furnish us with our most accurate determination of the mass of *Jupiter*. It is with great pleasure that we recall the attention of the Society to Krüger's determination of the mass of *Jupiter* from the perturbations which it produces in

the orbit of *Themis*.* The mass thus obtained is in perfect accord with the result derived from the motions of *Jupiter's* Satellites by Airy and Bessel.

Comet I. 1866.

This Comet, the only known one of the year, was discovered by Tempel, 1865, Dec. 19. The Comet was well observed, and passed its perihelion in the early part of January. Elliptic elements of its path were calculated by D'Arrest and Oppolzer. The excentricity however was large, and the part of its orbit described during its visibility small. The elements discriminating the elliptic motion are consequently not well determined. The periods assigned by D'Arrest and Oppolzer differ greatly. They are respectively 53 and 20 years.

Attention may here be called to a most curious and interesting speculation of Sig. G. V. Schiaparelli, that the Comet II. of 1862 is nothing more than one of the August meteors. Schiaparelli assumes for the radiant point of the August meteors in 1866,—

R.A. 41° N.P.D. 34°

and takes for the maximum of frequency

August 10·75 days.

He thence deduces the following parabolic orbit for these meteors :

Passage of Perihelion	23·620 July
Passage of descending Node	10·75 August
Longitude of Perihelion	343° 28′
Longitude of Ascending Node	138° 16′
Inclination	64° 3
Distance of Perihelion	0·9643
Motion retrograde	

The elements of the orbit of Comet II. 1862, are according to Oppolzer :

Passage of Perihelion	22·9 August 1862.
Longitude of Perihelion	344° 41′
Longitude of Ascending Node	137° 27′
Inclination	66° 25′
Distance of Perihelion	0·9626
Motion retrograde.	

Duration of revolution 123 years.

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* An abstract of Krüger's paper, by Mr. Lynn, will be found in the *Monthly Notice* for Nov. 9.

The agreement of these elements is striking. From this agreement Schiaparelli infers that the Comet II. of 1862 is nothing more than a very large meteor of the August system.

On Jan. 22, 1867, M. Stéphan discovered a telescopic comet at Marseilles.

Change on the Moon's Surface.

It is the opinion of Dr. Schmidt that changes are in visible progress on the surface of the Moon. Dr. Schmidt has been acquainted with the appearance of the Crater *Linné* since 1841, and able to see it, as a crater, with the optical means at his disposal, with ease. In the months of October and November 1866 this was no longer the case, even under the most favourable circumstance of illumination. The place of *Linné* appeared covered by a whitish cloudy patch. The crater appears to be now visible in our best telescopes, but no one unacquainted with the appearance formerly presented by *Linné*, from actual observation, can be in a position to speak definitely with respect to the nature of the changes which are supposed to have been in progress. Further information from Dr. Schmidt is awaited with great interest.

The Outburst in T *Coronæ.*

The most startling astronomical event of the past year has undoubtedly been the late outburst in the Star No. 2765 of Argelander's *Bonner Sternverzeichniss*, Zone + 26°. This Star, estimated by Argelander in 1855 as of the 9·5 magnitude, was seen by Mr. Birmingham at Tuam on May 12, between $11^h\ 30^m$ and $11^h\ 45^m$ local time, as a star of the 2nd magnitude. Dr. Julius Schmidt, of Athens, is perfectly convinced that the star was below the 4th magnitude at 11 P.M. Athens local time, on May 12. If the negative evidence of Dr. Schmidt can be trusted on this point, and his testimony on such a point must be entitled to the greatest weight, the star must actually have changed from below the 4th to the 2nd magnitude in less than three hours. An interesting series of observations of the magnitudes of this Variable, by Mr. Baxendell, will be found in the *Monthly Notice* for November 9, 1866. The important spectrum observations of this star by Mr. W. Huggins and Dr. W. A. Miller, fall naturally within the scope of our President's speech. It may however be mentioned, that, of the four bright lines seen by Messrs. Huggins and Miller, three were measured in position at the Greenwich Observatory, where a fourth, not apparently seen by Messrs. Huggins and Miller, was detected. Traces of the brightest lines were also observed with the great Equatoreal of the Greenwich Observatory, when the star had diminished below the 8th magnitude.

γ Cassiopeiæ.

An important discovery has been made by Father Secchi that the spectrum presented by T *Coronæ* is not perfectly unique amongst Star spectra. In the *Astron. Nach.* No. 1612, under date of 1866, August 23, Father Secchi states that the spectrum of *γ Cassiopeiæ* has one bright line in the place of Fraunhofer's solar line F, and several others too faint for position-measurement. This discovery of Father Secchi is the more unexpected, from no indications of variability having been detected in the star.

In a communication to the *Comptes Rendus*, tome lxiii. No. 16, under date September 8, 1866, Father Secchi also states that a spectrum of similar character is presented by *β Lyræ*. In the case of *β Lyræ* the lines are stated to be distinguished with great difficulty.

Celestial Photography.

An interesting and important extension of Photography to Astronomy has been lately made by Mr. Rutherford, of New York. Mr. Rutherford has succeeded in obtaining photographic impressions of stars down to the $8\frac{1}{2}$ magnitude, and over an area of a square degree. On the evening of 1866, March 10, Mr. Rutherford obtained three photographs of the *Pleiades*. With an exposure of four minutes he obtained impressions of forty stars. Dr. Gould has deduced from these plates the relative position angles and distances of the stars. A comparison of his results with those obtained by Bessel by direct micrometrical measurements proves at once the accuracy of the new method and the small amount of relative change which has taken place in this system during the last quarter of a century. The observations made by Bessel extended over more than eleven years. The observations of Mr. Rutherford were made in a single night, the subsequent reductions being made at leisure. Such is one of the results of the combined action of astronomers and chemists within the last few years.

The Companion of Sirius.

In our *Notice* for May will be found an interesting paper by M. Otto Struve, in which he endeavours to prove that the small star discovered by Mr. Alvan Clark near *Sirius*, is in physical connexion with that star, and the cause of the observed irregularities of its proper motion. M. Otto Struve compares his position angles and distances made from 1863 to 1866 with the results of the theoretical investigations of Dr. Auwers, "On the orbit of the disturbing body which pro-

duces the irregularities in the proper motion of *Sirius*" (*Ast. Nach.* No. 1506.) The agreement found between the observed and calculated quantities appears satisfactory; but the disturbing body is required to have a mass only less by about a third than that of *Sirius* itself. The star discovered by Alvan Clark appears at most of the 8th magnitude. Its physical constitution must therefore be very different from that of *Sirius* if it really be the disturbing body. If this most interesting speculation is confirmed we shall have a second independent astronomical discovery by theory,—a companion to the brilliant discovery of *Neptune*. An investigation, by Professor Newcomb, based upon different materials, but leading to a similar result, will be found in the *Astr. Nach.* 1584.

Reduction of D'Agelet's Observations.

An important addition to our Catalogues of ancient observations has lately been made by Dr. B. A. Gould. Dr. Gould has reduced the observations of fixed stars made by D'Agelet, at Paris, from 1783 to 1785. These observations were made with a Bird's Quadrant, which appears to have been seriously distorted by some accident. The method of reduction adopted is in essence differential, and the results depend fundamentally on the places of stars in the "Time Star List," prepared by Dr. Gould for the United States Coast Survey. By the process adopted the systematic errors of the instrument appear to be eliminated, and the Catalogue will probably form the best means at our disposal for the determination of the proper motion of all the stars which it contains and which are not contained in Bradley or Piazzi. The number of stars of which places are contained in the Catalogue is 2907.

Tables of the Planet Neptune.

During the past year Professor Newcomb has published New Tables of the Motion of the Planet *Neptune*. The objects proposed are stated as follows:—

1. To determine the elements of the orbit of *Neptune* with as much exactness as a series of observations extending through an arc of forty degrees will admit of.

2. To inquire whether the mass of *Uranus* can be concluded from the motions of *Neptune*.

3. To inquire whether these motions indicate the action of an extra-Neptunian planet, or throw any light on the question of the existence of such a planet.

4. To construct general tables and formulæ by which the theoretical place of *Neptune* may be found at any time, and, more particularly, at any time between the years 1600 and [illegible]

Professor Newcomb has not fully calculated the great inequalities resulting from the near commensurability of the mean motions of *Uranus* and *Neptune*, but has treated the effects produced as secular terms. The uncertainty attached to the mean motion of *Neptune* appears to render this course advisable. The greatest care has been taken to free the observations employed from systematic errors depending upon differences in the adopted places of fundamental stars of reference. Professor Newcomb concludes that the orbit of *Neptune* is not yet sufficiently well known to render the discovery of an extra-Neptunian planet (if such exists) by the disturbance it produces in the orbit of *Neptune*, at present possible.

Delaunay's Lunar Theory.

At the present moment are issuing from the press the last sheets of the second volume of Delaunay's great work on *The Lunar Theory*. This volume contains the completion of the problem proposed in the preface to the first volume:

"Déterminer, sous forme analytique, toutes les inégalités du mouvement de la Lune autour de la Terre, jusqu'aux quantités du septième ordre inclusivement, en regardant ces deux corps comme de simples points matériels, et tenant compte uniquement de l'action perturbatrice du Soleil, dont les mouvement apparent autour de la Terre est supposé se faire suivant les lois du mouvement elliptique."

Although the calculations are generally only carried to the seventh order, Delaunay has pushed the approximations to the ninth order in several inequalities where the convergency is slow.

The coefficients of all the inequalities are preserved in a literal form. Few who have considered the question will, we think, deny the great advantages resulting from this in the ease with which the results obtained can be compared with former investigations, the facility with which mistakes can be discovered and remedied, and the readiness with which the corrections resulting from improved data can be calculated.

In the second volume will be found the expressions for the longitude, latitude, and parallax, and the numerical values of the different terms. The numerical data are principally derived from Professor Airy's "Reductions of the Greenwich Lunar Observations."

In a third volume Delaunay promises to complete his Theory of the Motion of the Moon, by calculating the effects which result from the secular and periodic inequalities of the Sun's motion, the figures of the Moon and Earth, and the disturbing action of the planets. When the theory is thus completed, we hope that the formulæ will be reduced into tables. It would be out of place here to discuss the merits of the

method adopted by Professor Delaunay for the integration of the differential equation of the Moon's motion; a method differing essentially from those adopted by his predecessors;

The method is founded on the theory of variation of parameters, and may be briefly described as follows :—

If we suppose for a moment that the disturbing function were reduced to a non-periodic term together with a single periodic term, the differential equations which give the variations of the 6 elliptic elements might be readily integrated, and those elements expressed in terms of the time and 6 arbitrary constants.

Now the relations found on this restricted supposition may be supposed to hold good in the actual case in which the disturbing function is composed of many terms, provided that the 6 quantities which were arbitrary constants are now supposed to become functions of the time.

M. Delaunay has shown that if these new quantities be introduced into the equations instead of the original elliptic elements, their differential coefficients with respect to the time may be found by means of equations exactly similar in form to those with which we started, provided a new disturbing function be employed which is found by transforming the original disturbing function after omitting the periodic term which was considered in obtaining the relation between the old and the new parameters. By a series of operations of this kind, M. Delaunay successively removes the more important periodic terms of the disturbing function, until the terms remaining are so small that the square of the disturbing forces may be neglected, in which case the parameters finally employed may be obtained in terms of the time by direct integration.

The co-ordinates of the Moon are known in terms of the elliptic elements, and therefore by transformation can be expressed in terms of the parameters by which those elements were replaced, and so by successive transformations those co-ordinates may be expressed in terms of the new systems of parameters, and finally in terms of the time.

The process of integrating the equations of the Moon's motion is thus broken up into a series of operations, each of which is comparatively simple in character, and the accuracy of which can be readily examined.

Astronomers all over the world will look forward with intense interest to the completion of this noble work.

On the Probable Retardation of the Velocity of Rotation of the Earth by the Action on the Tides.

The discussion on this most important question has been

continued during the present year in a paper by the Astronomer Royal.

Treating the question as a hydrodynamical one, but confining his attention to an equatoreal belt of water, the Astronomer Royal has shown that, in this case, there would result a retardation of the velocity of the Earth's rotation as a necessary consequence of the lagging of the tides. The effect of great continental breaks is not considered. In the determination of the terms which produce the secular effects on the Earth's rotation, an assumption is made, that the position of an element of fluid at any time is independent of the initial position of that element. This simplifies the solution, but is in reality equivalent to assuming that no permanent currents can be produced in the fluid by the Moon's action. The same assumption is at the bottom of Delaunay's demonstration. A paper on this subject by Professor Sir W. Thomson appeared in the *Philosophical Magazine*, vol. xxxi. No. 212. The demonstration is essentially the same as Delaunay's. In this paper, however, some other causes are suggested as probably effective in producing a retardation of the Earth's rotation. In a note appended to the paper, Professor Thomson says: "It seems hopeless, without waiting for some centuries, to arrive at any approach to an exact determination of the amount of the actual retardation of the Earth's rotation by tidal friction, except by extension and accurate observations of the amount and times of the tides on the shores of continents and islands, in all seas, and much assistance from true dynamical theory, to estimate these elements all over the sea. But supposing these known for every part of the sea, the retardation of the Earth's rotation is easily calculated by quadratures."

In our *Monthly Notice* for May will be found an abstract of a paper by Mr. Ferrel, published so far back as 1853, in which it is insisted that a retardation of the Earth's rotation must be connected with observed phenomena of the tides. Mr. Ferrel's demonstration is essentially the same as Delaunay's. It must, we think, be admitted that the tidal friction must produce some retardation of the Earth's rotation; that we are here, in fact, dealing with a *vera causa*, but whether the whole of the outstanding quantity of lunar acceleration is due to this cause is perhaps still an open question.

Meteoric Astronomy.

No very remarkable additions have this year been made to our knowledge of the physical constitution and orbits of meteoric bodies beyond what has already appeared in the *Monthly Notices* of December last. The conviction, however, that henceforth their recurrence is to be regarded as a branch of Astronomical rather than of Meteorological inquiry has

become greatly confirmed. On this ground the recent November Star-shower was carefully and successfullly observed at Greenwich, by the direction of the Astronomer Royal, and at all the principal observatories.

Doubts have arisen regarding the hitherto presumed period and the circular form of the orbit of the great November congeries of meteors, arising from the fact, that the motion of its node does not appear to conform to the hypothesis of a circular orbit of 354 days, so ably advocated by Professor Newton. It is to be hoped that this interesting question will soon receive further elucidation.

Attention has already been called in another part of this report to the probability that Comet II., 1862, may after all be one of the larger of the August meteors. A question also arises whether the November congeries may not sometimes be visible, if sought for, in our larger telescopes. Doubtless now that the attention of competent astronomers is drawn to these subjects, much additional and trustworthy information regarding these cosmical substances will be gradually accumulated.

Information has just reached this country regarding a meteoric shower observed at noon-day on 1866, October 25, at Fremantle, West Australia.

Communications to the Society from February 1866 *to February* 1867.

1866.

Mar. 9. Notice of the great Nebula of *Orion*. Rev. T. W. Webb.

Additions to Investigations on Cometary Systems. M. Hoek.

Path of a Detonating Meteor. Mr. A. S. Herschel.

Note on the Companion to *Antares*. Mr. Freeman.

Investigations on Airy's Double-image Micrometer. Dr. Kaiser.

Occultation of 130 *Tauri*. Mr. Talmage.

On the Acceleration of the Moon's Mean Motion. Mr. Finlayson.

Spectrum of *α Orionis*. P. Secchi.

Ephemeris of *Iris* for Opposition of 1866. Dr. Brunnow.

On the Advantages gained by substituting a Refracting Prism for a Diagonal Mirror in a Silvered-glass Speculum. Mr. Browning.

On the Supposed Possible Effects of Friction in the Tides in influencing the Apparent Acceleration of the Moon's Mean Motion. Mr. Airy.

On the Semidiameter of the Moon. M. Oudemans.

On the New Star of the year 393 A.C. M. Goldschmidt.

April 13. On a small Star near ι *Canis Majoris.* Mr. Freeman.

On a Method of computing interpolations to the second order without change of Algebraic Sign. Mr. Airy.

Occultation of 31 *Arietis*, and supposed Observation of Biela's Comet. Mr. Talmage.

On the Companion to *Sirius.* Mr. Knott.

On the Companion to *Antares.* Mr. Cottam.

On the Variable in *Collo Cygni.* Mr. Stone.

On Solar Phenomena. Mr. Waterston.

May 11. Description of an Equatoreal Clock. Lord Oxmanton.

On the Satellite of *Sirius.* M. O. Struve.

Occultations and Phenomena of *Jupiter's* Satellites. Mr. Airy.

On the Spectrum of α *Orionis.* P. Secchi.

Results of some Observations on the Bright Granules of the Sun. Mr. Huggins.

Supposed Observation of Biela's Comet. Mr. Buckingham.

June 8. On the Effect produced by the Angles of Position of Double Stars.

On the Results of Micrometrical Measures of them, with a Description of a Method by which such Effect may be avoided or removed. Rev. W. R. Dawes.

Equatoreal Observations of *Mars* and Neighbouring Stars for the Determination of the Sun's Parallax, &c. Mr. Pogson.

Mean N.P.D. of *Rigel*, α *Orionis*, *Sirius*, and α *Hydræ*, from Observations with Transit Circle at the Cape of Good Hope. Sir T. Maclear.

Observations of the Spectrum of the extraordinary Variable near ε *Coronæ.* Mr. Stone.

Eye Estimations of Stars near *Corona.* Sir J. Herschel.

The New Variable Star. Mr. Chambers.

On the Craters of the Moon. Mr. Hodgson.

On the Depression of the Barometric Column by the Vapour of *Mercury*. Gen. Shortrede.

On the Spectrum of *Antares.* M. Secchi.

Nov. 9. On the Change in Elliptic Orbits from an accession to the Sun's Mass. Mr. Waterston.

The Value of the Sun's Gravitation Integral compared with the Annual Amount of Radiant Force expended. Mr. Waterston.

On the Change in an Elliptic Orbit if the Intensity of the Force of Gravity was influenced by Centripetal Velocity of the Orbital Body. Mr. Waterston.

On the Amount of Force that a given Mass may produce by its Force of Gravity.
Observations of the Solar Eclipse of Oct. 8, 1866. Mr. Joynson.
Morning Illumination of *Hipparchus*. Mr. Birt.
Rotatory Motion of the Planets. Mr. Rodgers.
On the Distribution of Solar Spotted Area in Heliographic Latitude. Messrs. De La Rue, Loewy, and Stewart.
On a New mode of Finding the Position of Solar Spots. Capt. Ashe.
On the Solar Eclipse of Oct. 8. Mr. Talmage.
On the Adjustment of the Sextant. Mr. W. Simms.
On a Double-image Micrometer. Mr. W. Simms.
Micrometrical Measurements of Double Stars. Rev. W. R. Dawes.
Observations of Planets and Nebulæ at Malta. Mr. Lassell.
Observations of the New Variable T *Coronæ*. Mr. Baxendell.
On Krüger's Mass of *Jupiter*. Mr. Lynn.
On the identity of the Variable T *Coronæ* with a Star in Wollaston's Catalogue. Mr. Stone.

Dec. 14. Meteoric Shower of Nov. 14. Adm. Ommanney.
Ditto ditto Mr. De La Rue.
Ditto ditto Rev. G. Venables.
Ancient Eclipse of the Sun observed in India. Mr. Peacock.
New Tables of Refraction. Capt. Shadwell.
Occultation of *Aldebaran*. Mr. Joynson.
Plan for Fixing Position of Solar Spots. Capt. Ashe.
On the Secondary Spectrum. Mr. Wray.
Observations at Malta with the 4-feet Equatoreal. Mr. Lassell.
Synopsis of Sir W. Herschel's Micrometrical Measurements of Double Stars. Sir John Herschel.
Meteoric Shower of Nov. 14. Sir J. Herschel.
Ditto ditto Mr. A. S. Herschel.
Ditto ditto Prof. C. P. Smyth.
Ditto ditto Mr. Hunter.
Ditto ditto Mr. Taunton.
Ditto ditto Rev. W. Deey.
Ditto ditto Rev. W. R. Dawes.
On the Use of the Eye-piece Micrometer in Measurements of Double Stars. Rev. W. R. Dawes.
On the Telescopic Disks of Stars. Mr. Knott.
Meteoric Shower of Nov. 14. Prof. Grant.
Ditto ditto Mr. Birmingham.
Speculations on Meteoric Trains. Major Tennant.

Inference from the Observed Movement of the Meteors in the appearance of 1866, Nov. 13. Mr. Airy.
On the Simultaneous Disappearance of *Jupiter's* Satellites in the year 1867. Mr. Airy.
The Annular Solar Eclipse of March 5–6, 1867. Mr. Hind.
Remarks on certain Observations of T *Coronæ* reputed to have been made by Mr. Barker, 1866, May 4. Mr. Stone.
Occultations observed at Maresfield. Capt. Noble.
On the possibility of a Change in the position of the Earth's Axis due to Frictional Action connected with the Phenomena of the Tides. Mr. Stone.
Meteoric Shower of Nov. 14. Rev. R. Main.
Ditto ditto Mr. Fasel.
Ditto ditto Mr. Hind.
1867. Ditto ditto Rev. F. Howlett.
Jan. 11. Ditto ditto Mr. Talmage.
Ditto ditto Mr. G.W.H. Maclear.
Observations of Total Eclipse of the Moon Sept. 20, 1867. Mr. Tebbutt, jun.
Observations of Lunar Crater *Linné*. Mr. Birt.
On the Spectra of the Meteors of Nov. 14, 1866. Mr. Browning.
Comparison of Sun-spot Observations by M. Schwabe with those made at Kew in 1866. Messrs. De La Rue, Loewy, and Stewart.
Occultations of Stars by the Moon and Phenomena of *Jupiter's* Satellites. Mr. Airy.
On the Solar Eclipse of August 1868. Major Tennant.
Measures of the Binary Star ζ *Herculis*. Rev. W. R. Dawes.
Meteoric Shower of Nov. 14. Mr. Lowe.
Luminous Meteors of Nov. 13, 1866. Rev. Prof. Challis.
On a Bright Meteor Nov. 13, 1866. Mr. Hodgson.

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ADDRESS

Delivered by the President, the Rev. Charles Pritchard, on Presenting the Gold Medal of the Society to William Huggins, Esq., F.R.S, F.RA.S., and W. A. Miller, M.D., F.R.S., Professor of Chemistry, King's College, London.

Your President now proceeds to that part of his duty, which if it be, as it is, among the most pleasant, is certainly also among the most anxious and important functions which he is expected to perform. He is to explain to you on what grounds your Council have awarded the annual Medal conjointly to Mr. W. Huggins and Professor W. A. Miller, and why on this occasion they have sought for and have obtained the concurrence of the Society at large, in departing from a course which for many years past the bye-laws of our Society, with much wisdom, have prescribed.

Many circumstances during the last few years have conspired to give to the cultivation of Astronomy a strong impulse in a new direction. Among the foremost of these we may notice the rapid advances which the science itself has made towards completeness in some of the most difficult and important branches of its ancient and manifold research. The old problem, for instance, of the determination of the longitude at sea has been, in its theoretical aspect, satisfactorily disposed of. The positions of the celestial fieldmarks in the northern hemisphere have been well ascertained and conveniently recorded ; the elements and the disturbing forces of the planetary orbits are known for the most part within satisfactory limits ; and by the aid of a most refined analysis, combined with long-continued, patient, and sagacious observations, the motions of our own more refractory satellite have at length been reduced to calculation with an unhoped-for degree of precision and success. As far as these, the prime objects of astronomical research are concerned, comparatively little now remains to be desired, and the gradual rectification of that little,—(for in Astronomy I may not speak of completeness, seeing that in it, though the most precise of the sciences, little or nothing can be regarded as absolute and final)—I say that for the gradual rectification of what remains to be achieved, we must now abide the slow processes of time to give an enlarged breadth to the differences of astronomical epochs, or we must wait for fresh observations at the occurrence of suitable but rare opportunities. So rapid has been the progress of our Science

that there are those now sitting in this room who may well remember how on an occasion similar to the present, one of the ablest of the long line of your eminent Presidents threw out the suggestion that possibly the law of gravitation itself might be found to fail at distances so remote as that of the Planet *Uranus*. Another had previously remarked, that it was conceivable some different law of force might prevail amidst the stars; while more recently the subtle and refined investigations of the Moon's mean motion by a third, led to at least the momentary suspicion, that after all that had been done, some of the consequences flowing from the law of gravitation might not be fully within the grasp of modern analysis. Nevertheless, the very same race of (happily for us) still living astronomers who had become perplexed at the occurrence of these not unreasonable suspicions, have witnessed also their entire removal: the removal of the first suspicion by the discovery of *Neptune;* of the second, by the coincidence of the observed motions of not a few of the double stars with gravitational orbits; and of the third, by the now indubitable influence of lunar and tidal action on the diurnal rotation of the Earth. The realms then of the science which we cultivate having thus become either established or in process of establishment within her ancient landmarks, what wonder is there if we find ourselves assembled to-day for the grateful task of conferring the highest honour which our Society can bestow on gentlemen who have successfully broken for us fresh ground, and have commenced the enlargement of its borders in a new, a hopeful, and (I may be pardoned for saying) a most fascinating direction?

Nor is the rapid advance of Astronomy towards completeness in the fields which she has for the most part hitherto occupied, the only cause which has contributed to this result. Concurrently with this advance we find a remarkable enlargement of the optical power of refracting telescopes, and in the wide extent to which these powerful instruments are multiplied. This signal improvement and wide distribution of the chief instrument of astronomical research would of itself be sufficient to indicate the new direction which our science might be expected naturally to assume. And then again the vast and rapid strides of late years taken in our practical knowledge of the sciences of heat, electricity, chemistry, and light, have not only lent a new and unexpected aid to the prosecution of Astronomy, but have unavoidably given and directed a new bias to the objects of her research. It is well known that less than fifty years ago, when the elder Struve commenced his illustrious career at Dorpat, the largest telescope available for his use was one constructed by our countryman Dollond, of which the aperture was less than four inches. At the present day, admirably furnished instruments, exceeding the double of that aperture, are as we are

all aware, in the hands of many private observers in comparative abundance. Nay, further than this, an English artist, and a member of your own Council, has nearly completed an object-glass of the unparalleled aperture of twenty-five inches. How heartily he carries with him the good wishes of our Society for ultimate success in his arduous attempt it is needless for me to say.

If we who cultivate the most precise and exact of the sciences may be permitted for a moment to give reins to our imaginations, let us conceive the shade of our inimitable Troughton revisiting our National Observatory, which in the earlier decades of our century was rendered by his genius, in an instrumental point of view, without a rival in Europe. How would he be astonished to find the grand old Transit, and the exquisite Mural Circle which his own hands had constructed with consummate skill, now hanging on the walls of Greenwich, in honoured repose, and replaced by *one* gigantic implement which he would be the first to say may well serve as a monument to the intellectual powers of the present Director, and as a record of that strong faith in the resources of his art which alone in the first instance could have inspired him with hardihood to design the instrument, and in the second could have armed him with perseverance to bring it to completion. With what curiosity would the shade of the great artist peer about the strange wires and springs which seem to encumber the eye-piece; and how great would be his surprise when told that along these wires, by the aid of a chemistry the most refined, a subtle influence is conveyed to a distant room which there records with infallible precision the very tenths of the seconds of time when each phenomenon is observed. And as he recognised the old faithful and familiar clock, how great would be his admiration when he learnt that it no longer beats in the impressive solitude of its former days, but, when bidden, transmits and records its every pulsation, with unerring and instantaneous certainty, now at Valentia, now at Paris, now at Berlin, now at the farthest confines of civilized Europe, and perhaps is destined to dart, like a thing of life, the very spirit of its presence across the abysses of the Atlantic to Astronomers who will wait for and welcome the signal in the Observatories of Boston or New York. Such, then, being the progress which men, true to their mission and to their day, have been permitted to make in the march of science, it can excite no fresh surprise that henceforth they aim at a loftier flight, and no longer conceiving that the grasp of human knowledge is restricted to perchance the weighing of the stars and the measuring of their distances, they begin to hope they have been destined to learn at least some little of their material and mineral constitution. It is not long since that from this Chair the Medal of our Society was worthily placed in the hands of one who, beyond the

average even of Astronomers, toned down and disciplined his imagination to the most rigid precision of naked fact,—his absence to-day, and still more the lamentable cause of it, we all deplore,—but even this unimpassioned and exact Astronomer, when he had concluded his laborious work of tabulating and delineating the Sun-spots of many a year, cannot succeed in stifling the yearnings of a natural curiosity, but concludes his volume (itself a sufficient monument of the labour of a life) with, from him, this unexpected question—"What is a Sun?"* To this question there has since arisen this further query, the cognate and equivalent of the former—"What is a Star?"

For the first dawning of a distinct and intelligent reply to this question we are indebted to Messrs. Huggins and Miller; and it is the acknowledgment of their successful labours in this behalf, which forms one of the main objects of our assembly to-day. And here I feel it impossible to repress the expression of the thought—(I had almost said the exultation)—that the elder among us who in our generation have witnessed the introduction of gas into our streets,† of steam into our ships and on our rails; that same generation, which has seen the very light itself constrained to form our pictures and record our observations, while the congener of the lightning has been chained in iron channels to convey the messages of our wills; that same generation, which has seen our rivers and estuaries spanned by tubular bridges, and wires laid across the entire bed of the Atlantic; has now been permitted by the Supreme Wisdom to understand some little of the processes from whence arise the heat and the light of the Sun, and what are the sources of those paler fires which come spangling to us from the more distant stars.

I should not have considered myself justified in thus occupying the time of the Society by the recital of these amazing results of the activity of the human mind in the nineteenth century,‡ if I did not regard them as among the proximate

* Carrington, Observation of Sun-spots, Preface, p. 17.

† In 1822 lighting by gas was becoming general in London. The first steam-vessel on the Thames plying between London and Margate was the "Majestic" in 1816, but it is said there were at that date about eighteen steam-boats on the Clyde. The first passage by steam only across the Atlantic was performed by the "Great Western" in 1838. The voyage from Bristol to New York was performed in fifteen days.

‡ I cannot here refrain from quoting a remarkable passage of great eloquence addressed to the House of Commons by one of our chief statesmen, three days after the delivery of this Address to the Astronomical Society. In speaking of the wonderful social advances observable in England during the last ten years, Mr. Disraeli says: "I will not now attempt to inquire into the causes, the particular causes, which have brought about that great advance. But I think I may say there is one sovereign cause which is at the bottom of everything, and that is, the increased application of science to social life. That I believe to be the main cause of the vast changes we have seen in the condition and feelings of classes. We are all familiar with the material results which the application of science has produced. They are

causes of the culture of the new branches of Astronomical Physics, rather than as their merely casual antecedents. Further still, I think I am correct in affirming that it is only within the last few years, and then only in consequence of inventions* founded on the most refined physical researches, that it has become possible to obtain the spectrum of a star or nebula with that practical convenience and extreme precision necessary for identification or comparison with other spectra, and still less possible to interpret its physical significance when thus obtained.

I shall now proceed to give a rapid detail of those successive steps which at length enabled our Medallists of the present year to commence their researches into the material constitution of some of the celestial bodies, with a reasonable prospect of success; but in so doing, I shall confine myself to such discoveries alone as constitute essential and salient landmarks in the progress of the work.

It was our countryman, Dr. Wollaston, who in the year 1802 for the first time observed a few of the more conspicuous dark lines in the solar spectrum. He does not appear to have regarded his discovery as of any further importance beyond the fact, that he thought these lines formed actual and generic lines of separation between the distinctive colours of the spectrum. Now that we have learnt the physical significance of these interruptions in the solar light, it is not without some interest we remark, that the same volume of the *Philosophical Transactions*, which contains this first publication of Wollaston's discovery, contains also the first account of Dr. Young's researches into the undulatory theory of light. The instrumental appliances which enabled Dr. Wollaston to observe the new phenomenon were few and simple. A thin line of *diffused day-light*, furnished by an aperture in a window-shutter, and a moderately good prism held close to the eye, constituted all the apparatus necessary then, or essential now, for seeing with distinctness some four or five of the more prominent of the lines in question. Had Newton a century before that day placed his prism close to his eye, instead of receiving the spectrum on a screen, it seems almost certain that he must have anticipated Wollaston's discovery.

prodigious; but, to my mind, the moral results are not less startling. The revolution in locomotion, which would strike us every day as a miracle if we were not familiar with it, has given the great body of the inhabitants of this country in some degree the enlightening advantages of travel. The mode in which steam power is applied to the printing-press in these days produces effects more startling than the first discovery of printing in the 15th century. It is science that has raised wages; it is science that has increased the desires and the opportunities of men; and it is science that has ennobled labour and has elevated the condition of the working classes."

* It would be both curious and instructive to trace how far these inventions have been facilitated by Wollaston's invention of the manufacture of *platinum*.

Thirteen years after the publication of Wollaston's memoir, Fraunhofer, by placing a prism of exquisitely pure glass in front of a small telescope, and then and therewith viewing a distant and narrow line of direct *sun-light*, observed and measured the positions of hundreds of these lines which had escaped his predecessor's rougher survey, with a degree of precision not surpassed at the present day; and henceforth with much propriety they have borne, and probably will ever continue to bear, his name.

The younger among us may be disposed to smile incredulously when they are told how very few were the eyes in this country thirty or forty years ago which had ever enjoyed a sight of these mysterious lines. But owing to unfortunate fiscal restrictions in England besetting the manufacture of glass, prisms of an available quality were extremely rare. Moreover, it was not until the year 1848 that Troughton's colleague, Mr. Simms,* ingeniously adopted the collimating lens in the focus of the narrow slit, which now renders the Spectroscope the compact and manageable instrument with which we are familiar. Nor herein ought we to forget the services rendered in this country by Mr. Browning and others in the abundant manufacture of admirable prisms at a moderate cost. But, however all this may be, certain it is that for many years after the discovery of Fraunhofer's Lines, they were but rarely observed, and always spoken of with a species of *mysterious awe*. The suspicion that these interruptions in the solar light arose in some way from some absorption somewhere, either in the Sun itself or in our atmosphere, was naturally insisted on by various writers, but by no one more strongly and intelligently than by Sir John Herschel in his well-known *Treatise on Light*. Sir David Brewster, by an admirable experiment, added great force and gave a definite direction to this very probable suggestion. In the year 1832, just thirty years after Wollaston's discovery, this eminent philosopher examined the spectrum of light after it had passed through the coloured vapour of nitrous gas, and the result was the production of a vast number of dark linear interruptions in the luminous ribbon, which certainly resembled, and at first sight seemed to be identical with, Fraunhofer's Lines. Exact measurements, however, soon dispelled the notion of this identity; and other experiments, undertaken by Prof. Daniell, of King's College, London, and by Prof. Miller, of Cambridge, with other coloured vapours, demonstrated that these absorption lines in the spectrum were generically peculiar to the particular vapour through which the light had been made to pass before its dispersion by the refracting prism. Thus, what were at least the analogues to Fraunhofer's Lines could now be produced at will, by means comparatively rough and

* I have since been informed that Mr. Simms introduced this capital improvement of a collimator rather than a *distant* slit, at the suggestion of the present Astronomer Royal.

ready, and a new interest and additional mystery were thrown around these remarkable phenomena. The Sphinx had proposed and had now repeated her riddle, but as yet the Œdipus was not.

About three years after Sir David Brewster's experiment, Prof. Wheatstone made what has since proved to be a great advance towards the explanation of the phenomena in question. This ingenious philosopher in the year 1835 discovered that the spectra produced by the incandescent vapours of several of the metals consisted of a comparatively few detached bright lines separated from each other by wide intervals of darkness. So definite were these bright lines in their relative arrangement, and so generically peculiar for each metallic vapour examined, that Prof. Wheatstone did not hesitate to declare that, "*by this mode of [prismatic] examination, the metals might be distinguished from each other*."* We have here, then, the exact reverse of the phenomenon observed by Wollaston and Fraunhofer in light emanating from the Sun: they showed that the spectrum of solar light is a bright luminous ribbon interrupted by dark lines; and here Wheatstone exhibits the spectra of metallic vapours as dark ribbons crossed by bright lines in definite arrangement.

If this were the fitting place, or the proper occasion, it would now be both interesting and instructive to trace and to narrate the successive close approximations made by successive philosophers towards the true explanation of the phenomena before us. One or another of them was more than once on the very threshold of that simple generalisation, which, as the province and the privilege of a great truth, was destined at length to systematise and grasp the whole. What now took place between the year 1835, when Brewster and Wheatstone had recorded the result of their researches, and the year 1859, when Kirchhoff happily grouped all the phenomena in one consistent whole, very much resembles what occurred just before the discovery of gravitation by Newton, and (at a more recent period) what occurred in the history of chemical philosophy before the great works of Lavoisier and Dalton. But what is it, we may ask—what is it which, as it were, causes coming and substantial discoveries so often to throw their shadows before them? Is it some single word, or some chance expression, which, as a winged seed falling from one master mind is wafted, like a rumour, amongst other minds, until at length it finds a proper and a kindred home, and then germinates and fructifies into the ripeness of the expression of a general truth? Or is it that the minds of men, after some unknown process, and in accordance with some magnificent prearrangement by the Great Eternal Mind, become from time to time, by the interaction of circumstances,

* For Mr. Fox Talbot's discovery see Appendix C.

polarised, and, when the tension becomes extreme, break forth at length into the force and the light of discovery?

Whatever may have been the cause or causes, it may safely be asserted of Foucault in 1849, of Stokes in 1850, of Angström in 1855, and of Balfour Stewart in 1859, that each of them was in possession of and enunciated truths, which, had they been traced to their natural and inevitable consequences, must have led to that grand generalisation which will immortalise the name of Kirchhoff, and which forms one of the happiest and most remarkable discoveries of modern times.*

What Kirchhoff did was virtually this:—In 1859 he propounded as a great natural law, that if a vapour, when sufficiently heated, possesses the property of emitting lights of certain refrangibilities, that vapour at a lower temperature has a tendency to absorb or refuse a passage to lights of the same refrangibilities which may be incident upon it. Kirchhoff demonstrated this law experimentally in the cases of Sodium, Lithium, Potassium, Strontium, Calcium, and Barium. From the vapours of each of these metals he obtained those spectra consisting of intermittent *bright* lines of which I have spoken, and then viewing these spectra through less intensely heated vapours of the same metals, the bright lines became reversed into *dark* lines.† Here then we appear to possess a satisfactory explanation of the Fraunhofer dark lines of the solar spectrum. The solid or liquid superficies of the Sun may be presumed to be incandescent, and hence as a solid or liquid to emit rays of light ranging through a vast variety of refrangibilities. Above this incandescent superficies we may conceive heated vapours of various metals or other ingredients to float; these vapours will absorb, intercept, or be opaque to rays of light of various refrangibilities, and hence, by this simple process, may arise in the solar spectrum the dark lines discovered by Wollaston and Fraunhofer. In order to put this hypothesis to the test, Kirchhoff, in 1860, caused a very powerful Spectroscope to be constructed for him by Steinheil of Munich, so arranged as to permit him to observe the spectra of the vapours of several metals in juxta- or super-position with the solar spectrum; and in this way he identified the bright lines of the vapours of iron, copper, magnesium, and of other substances, with the dark lines of the solar spectrum.

A mode of analysis thus strangely independent of the distance of the body analysed, naturally possesses peculiar attractions for those who are engaged in the observation of celestial objects. In the hands of Kirchhoff it had already been suc-

* For particulars see the Appendix C to this address.

† It is important here to observe that the *heated vapours* themselves *emit* some rays of the same character as those which they have wholly absorbed, but they are so *feeble* as to appear *dark* in contrast with the adjacent lights in the spectrum.

than reproduce them here exactly as they stand in the *Philosophical Transactions.* They say:—

"These spectrum observations are not without interest also when viewed in connexion with the *nebular hypothesis* of the cosmical origin of the solar system and fixed stars. For if it be supposed that all the countless suns which are distributed through space, or at least those of them which are bright to us, were once existing in the condition of nebulous matter, it is obvious that, though certain constituents may have been diffused throughout its mass, yet the composition of the nebulous material must have differed at different points; otherwise, during the act of agglomeration, each system must have collected and condensed equal proportions of similar materials from the mass around. It cannot be supposed that similarity in physical properties has caused the association of the different elements: we find, for example, some of the least volatile of the metals, such as iron, associated with highly volatile elements, such as mercury and tellurium, in the same star.

"If we may so say, there seems to be some analogy between this irregular distribution of the elements in different centres in space, and the manner in which the components of the earth's crust are distributed. Upon the earth there are certain very generally diffused elements, such as oxygen, hydrogen, carbon, silicon, iron, aluminium, and calcium, which occur in all parts; whilst there are others which, like silver, tin, lead, and other metals, are accumulated at particular points only. Whatever may have been the physical causes which may have produced this separation, we see abundant evidence of the advantage of this distribution in their application to the purposes of man—smallness in relative amount being compensated for by the accumulation of the material in denser deposits, which allow of their comparatively easy extraction to supply the wants of mankind. If this arrangement be admitted as designed in the case of the earth, is it going beyond the limits of fair deduction to suppose that, were we acquainted with the economy of those distant globes, an equally obvious purpose might be assigned for the differences in composition which they exhibit?

"The additional knowledge which these spectrum observations give us of the nature and of the structure of the fixed stars, seems to furnish a basis for some legitimate speculation in reference to the great plan of the visible universe, and to the special object and design of those numerous and immensely distant orbs of light.

"The closely marked connexion, in similarity of plan and mode of operation, in those parts of the universe which lie within the range of experiment, and so of our more immediate knowledge, renders it not presumptuous to attempt to apply

the process of reasoning from analogy to those parts of the universe which are more distant from us.

"Upon the earth we find that the innumerable individual requirements which are connected with the present state of terrestrial activity, are not met by a plan of operation distinct for each, but are effected in connexion with the special modifications of a general method embracing a wide range of analogous phenomena. If we examine living beings, the persistence of unity of plan observable amidst the multiform varieties of special adaptation of the vertebrate form of life may be cited as an example of the unity of operation referred to. In like manner the remarkably wide range of phenomena which are shown to be reciprocally interdependent and correlative of each other, by the recent great extension of our knowledge in reference to the relation of the different varieties of force and their connexicn with molecular motion, exhibits a similar unity of operation amidst the changes of the bodies which have not life.

"The observations recorded in this paper seem to afford some proof that a similar unity of operation extends through the universe as far as light enables us to have cognizance of material objects. For we may infer that the stars, while differing the one from the other in the kinds of matter of which they consist, are all constructed upon the same plan as our sun, and are composed of matter identical, at least in part, with the materials of our system.

"The differences which exist between the stars are of the *lower order*, of differences of *particular adaptation*, or special modification, and not differences of the *higher order* of distinct *plans of structure*.

"There is therefore a probability that these stars, which are analogous to our sun in structure, fulfil an analogous purpose, and are, like our sun, surrounded by planets, which they by their attraction uphold, and by their radiation illuminate and energize. And if matter identical with that upon the earth exists in the stars, the same matter would also probably be present in the planets genetically connected with them, as is the case in our solar system.

"It is remarkable that the elements most widely diffused through the host of stars are some of those most closely connected with the constitution of the living organisms of our globe, including hydrogen, sodium, magnesium, and iron. Of oxygen and nitrogen we could scarcely hope to have any decisive indications, since these bodies have spectra of different orders. These forms of elementary matter, when influenced by heat, light, and chemical force, all of which we have certain knowledge are radiated from the stars, afford some of the most important conditions which we know to be indispensable to the existence of living organisms such as those with which we

are acquainted. On the whole, we believe that the foregoing spectrum observations on the stars contribute something towards an experimental basis on which a conclusion, hitherto but a pure speculation, may rest, viz. that at least the brighter stars are, like our sun, upholding and energizing centres of systems of worlds adapted to be the abodes of living beings."

It was natural that these gentlemen should in the course of their research turn their thoughts to that remarkable variety of colour which even to the unassisted eye is apparent among the stars. As far as their investigations have yet proceeded, it appears that these varied colours arise not so much from the existence of substances which copiously emit the colours observed, as from substances whose heated vapours absorb the colours complementary to them. For instance, the observed or apparent colour of a star is red, simply or mainly because its heated vaporous envelope absorbs much of the light at the blue end of the spectrum. In connexion with these varied colours of the stars, there is a very interesting remark made by one of our Medallists, which it is desirable to quote; it is as follows:—

"The presence in the atmospheres of *Aldebaran* and *α Orionis* of metals, such as iron, which require an exceedingly high temperature to convert them into vapour, renders untenable the supposition, which might otherwise have been entertained, that the orange and red tints of the light of these stars might be due to an inferior degree of incandescence of the photosphere as compared with the temperature of the stars the light of which is white."

Their observations seem also to afford additional reasons for doubting the existence of any effective atmosphere in the Moon, and for suspecting the existence of a dense and even peculiar atmosphere round the planet *Jupiter;* moreover, they lead to the suspicion that *aqueous vapours* like our own form a part of the atmospheric envelopes of *Jupiter* and *Saturn.*

When the first series of these remarkable observations was completed, Mr. Huggins commenced his inquiries into the constitution of Nebulæ and Comets. But the feeble luminosity of these bodies or congeries of bodies at once interposed an additional obstacle. Nevertheless, I will not say the good fortune which not seldom attends on the adventurous, but I may say, the happy results which generally reward strong faith in the truth of a principle, here befriended Mr. Huggins in no slight degree. The light from such nebulæ as heretofore have been unresolved even by Lord Rosse's reflector, turn out in most cases to be nearly mono-chromatic, and consequently when observed through the prisms was not dispersed over a long ribbon of light, becoming thereby so feeble as to defy

the discrimination of still darker lines if such existed.* But here I cannot do better than describe the phenomena in Mr. Huggins' own language: he is speaking of one of Herschel's nebulæ in *Draco*, small and comparatively bright, with a small nucleus; and he says:—

"My surprise was very great, on looking into the small telescope of the spectrum apparatus, to perceive that there was no appearance of a band of coloured light, such as a star would give, but in place of this, there were three isolated *bright lines* only.

"This observation was sufficient to solve the long agitated inquiry in reference to this object at least, and to show that it was not a *group of stars*, but a *true nebula*.

"A spectrum of this character, so far as our knowledge at present extends, can be produced only by light which has emanated from matter in the *state of gas*. The light of this nebula, therefore, was not emitted from incandescent solid or liquid matter, as is the light of the Sun and stars, but from *glowing or luminous gas*.

"It was of importance to learn, if possible, from the *position* of these bright lines, the chemical nature of the gas or gases of which this nebula consists.

"Measures taken by the micrometer of the most brilliant of the bright lines showed that this line occurs in the spectrum very nearly in the position of the brightest of the lines in the spectrum of nitrogen. The experiment was then made of comparing the spectrum of nitrogen directly with the bright lines of the nebula. I found that the brightest of the lines of the nebula *coincided* with the strongest of the lines which are peculiar to nitrogen. It may be, therefore, that the occurrence of this one line only, indicates a form of matter more elementary than nitrogen, and which our analysis has not yet enabled us to detect.

"In a similar manner the faintest of the lines was found to coincide with the green line of hydrogen.

"The middle line of the three lines which form the spectrum of the nebula, does not coincide with a very strong line in the spectra of about thirty of the terrestrial elements. It is not far from the line of barium, but it does not coincide with it. Besides these bright lines there was also an exceedingly faint continuous spectrum. This spectrum had no apparent breadth, and must therefore have been formed by a minute point of light. Its position crossing the bright line about the middle showed that the point of light was situated about the centre of the nebula. Now this nebula possesses a minute but bright

* The intensity of the light of certain nebulæ as measured by Mr. Huggins, varied from $\frac{1}{1508}$ to $\frac{1}{19604}$ of the light of a sperm candle, "six to the pound," viewed at the distance of 440 yards and consuming about 158 grains of the material per hour. *Phil. Trans.* 1866, p. 396.

nucleus. We learn from this observation that the matter of the nucleus is almost certainly not in a state of gas, as is the material of the surrounding nebula. It consists of opaque matter, which may exist in the form of an incandescent fog of solid or liquid particles." Thus the incandescent gaseous constitution of at least some of the nebulæ appears to be demonstrated by this remarkable method for research.

While these observations were still in progress, Mr. Huggins availed himself of the apparition of the only Comet visible in 1866; and although Donati had previously given a diagram of a cometic spectrum, Mr. Huggins is the first person who has attempted a rigorous interpretation of what the spectrum actually implies. The following is the account which he gives:—

"It was a nearly circular, very faint vaporous mass. Nearly in the centre, a small and rather dim nucleus was seen. When this object was viewed in the spectroscope, two spectra were distinguished. A very faint continuous spectrum of the coma showing that it was visible by reflected solar light. About the middle of this faint spectrum, a bright point was seen. This bright point was the spectrum of the nucleus, and showed that its light was different from that of the coma. This short *bright line* indicated that the nucleus of this comet was self-luminous; and further, the position of this line in the spectrum suggested that *the material of the comet was similar to the matter of which the gaseous nebulæ consist.*"

The account which I have so far given includes the most laborious, and perhaps the most important researches of our Medallists in Astronomical Physics; but unquestionably the most remarkable result still remains to be detailed. Herein, again, we shall find another instance of that good fortune and success which so commonly attends, not so much the bold, as the well prepared. It appears that on the night of the 12th of May last, what appeared to be a new star was seen in *Corona Borealis* by Mr. Birmingham, of Tuam, and he describes it as "very brilliant and of about the second magnitude." It is scarcely probable that a gentleman sufficiently observant to detect an apparently new star could be greatly mistaken as to its relative magnitude. This remark is not without its significance, inasmuch as Dr. Schmidt, the able astronomer at Athens, confidently states that *three hours before* Mr. Birmingham had seen it, the star could not have reached the fourth magnitude, and consequently there must have been an increase of brightness from at least that of the fourth magnitude to that of the second in the short space of three hours. This sudden outburst of a new celestial light carries us backwards three centuries to the days of Tycho Brahe, who witnessed the apparition of a star as bright as *Sirius*, and which he was sure had not been visible half-an-hour before. The great Danish astronomer, unfortunately for

us, had not the means and appliances which since his day have accumulated in the hands of our modern observers, and little else was left for him to do but to gaze, and guess, and be astonished. Our Medallists were better prepared, not only with instrumental aid, but with that knowledge which is the offspring of experience and toil. Intelligence of the outburst of this star reached them on the 16th of May, four days after its detection by Mr. Birmingham, and on the night of the same day they hastened to examine it with their spectroscope. Not even Galileo, when with his first telescope he discovered the satellites of *Jupiter*, and at once had the skill to decipher the import of the new revelation, could have been more astonished than were Messrs. Huggins and Miller, when before their eyes there lay the evidence which suggested the atmosphere of a star, a sun, a world, *on fire*. What the writing was which they saw written on the walls of heaven, and what was the interpretation thereof, I cannot do better than set forth in the accurate and measured language of our Medallists themselves :—

"When the spectroscope was placed on the telescope, the light of this new star formed a spectrum unlike that of any celestial body which we have hitherto examined. The light of the star is compound, and has emanated from two different sources. Each light forms its own spectrum. In the instrument these spectra appear superposed. The principal spectrum is analogous to that of the sun, and is evidently formed by the light of an incandescent solid or liquid photosphere, which has suffered absorption by the vapours of an envelope cooler than itself. The second spectrum consists of a few *bright lines*, which indicate that the light by which it is formed was emitted by matter in the state of luminous gas.* . . . .

"It is difficult to imagine the present physical constitution of this remarkable object. There must be a photosphere of matter in the solid or liquid state emitting light of all refrangibilities. Surrounding this must exist also an atmosphere of cooler vapours, which give rise by absorption to the groups of dark lines.

"Besides this constitution, which it possesses in common with the sun and the stars, there must exist the source of the gaseous spectrum. That this is not produced by the faint nebulosity seen about the star is evident by the brightness of the lines, and the circumstance that they do not extend in the instrument beyond the boundaries of the continuous spectrum. The gaseous mass from which this light emanates must be at a much higher temperature than the photosphere of the star; otherwise it would appear impossible to explain the great brilliancy of the lines compared with the corresponding parts

* See diagram of the Spectrum, *Monthly Notices*, vol. xxvi. p. 297.

of the continuous spectrum of the photosphere. The position of two of the bright lines suggests that this gas may consist chiefly of hydrogen.

"If, however, hydrogen be really the source of some of the bright lines, the conditions under which the gas emits the light must be different from those to which it has been submitted in terrestrial observations; for it is well known that the line of hydrogen in the green is always fainter and more expanded than the brilliant red line which characterizes the spectrum of this gas. On the other hand, the strong absorption indicated by the line F of the solar spectrum, and the still stronger corresponding lines in some stars, would indicate that under suitable conditions hydrogen may emit a strong luminous radiation of this refrangibility.

"The character of the spectrum of this star, taken together with its sudden outburst in brilliancy and its rapid decline in brightness, suggest to us the rather bold speculation that, in consequence of some vast convulsion taking place in this object, large quantities of gas have been evolved from it, that the hydrogen present is burning by combination with some other element and furnishes the light represented by the bright lines, also that the flaming gas has heated to vivid incandescence the solid matter of the photosphere. As the hydrogen becomes exhausted, all the phenomena diminish in intensity, and the star rapidly wanes.

"The purely speculative idea presents itself from these observations, that *hydrogen* probably plays an important part in the differences of physical constitution which apparently separate the stars into groups, and possibly also in the changes by which these differences may be brought about."

I will here add that by the 24th of May, the brightness of the star had diminished to that of a star of the eighth magnitude, and from observations taken at Greenwich it was recognised as a star already tabulated as 2765 of Argelander's Zone + 26°, being at the time of his observation of the ninth magnitude. Since this time it has been constantly watched, and certain of its variations recorded by Mr. Baxendell of Manchester, whose name is honourably associated with observations on this and on many other stars.

The last clause in the communication of our Medallists on May 17, 1866, to the Royal Society, was in a measure prophetic, inasmuch as Padre Secchi of the Collegio Romano, with that intelligence and zeal for which in this and other branches of Astronomy he is so conspicuous, has discovered traces of *hydrogen* in a luminous condition in at least one star, γ *Cassiopeiæ*, which has hitherto exhibited no trace of variability.

Thus we are probably approaching some further development of our knowledge of the material constitution of worlds and suns for the possibility of which our forefathers did not

so much as venture to hope, and which has come upon ourselves so suddenly as to excite our surprise. But I cannot conclude this, after all, inadequate account of a series of researches leading to some of the most startling and unexpected discoveries of modern times, without alluding to a thought which one of our Medallists briefly yet effectively touched upon in his exposition of these subjects before the meeting of the British Association at Nottingham in September last. And it is this ; the conflagration in this atmosphere of a star was first *observed* on the 12th of May, 1866 ; but when did it actually *occur?* If this star, henceforth to be called T *Coronæ*, is as near to this our world as is the nearest yet known of the stars, which proximity nevertheless we have no reason to suppose, then the increased outburst of the combustion of hydrogen must have taken place at least three years before it was visible at Tuam and interpreted at Tulse Hill. But if, as is far more probable, this star is among those more distant orbs which shine with a light so pale as to be visible only in our more powerful telescopes, then the conflagration, of which the first tidings have reached us only to-day, must have actually waxed and waned for its little week, not now nor yesterday, but it may be even hundreds of years ago.* The imagination shrinks within itself at the thought, how the bright light from that evanescent ephemeral outburst, winged its way, leaping century through century, from world to world, and telling successively the tale of its glory to (it may be) creatures nobler and more intelligent than ourselves, at length reaches the little speck of our mortal abode, in its course onward we know not whither. Such are the thoughts which are the natural inheritance of the inspiring yet difficult science which it is our lot to cultivate in this place ; and perhaps you will pardon your President for, on this auspicious occasion, momentarily giving way to the expression of emotions, which it would be as unphilosophical wholly to stifle, as it is unwise not to control. It is not the prism, it is not the electric heat, it is not the telescope, which reveals these things to the initiated eye, but the knowledge comes to us through the dutiful appliance of that subtle irrepressible spirit in the human mind, which was breathed into man from the Spirit of the Eternal.

Gentlemen, I have thus made it my endeavour to remind you, in the first place, how the progress which Astronomy has made towards completeness in most of her ancient departments naturally suggested the commencement of researches in some new direction. In the second place, I have intimated that, owing to the rapid advance of the experimental sciences, the new direction would naturally be rather towards the Physics,

* Herschel's *Outlines of Astronomy*, Articles 802, 803.

than the Dynamics of Astronomy; towards inquiries into the material constitution of the heavenly bodies, rather than into the laws for the relations of their motion. Lastly, I have endeavoured to lay before you how rich, and varied, and early, have been the fruits which your Medallists have gathered from the new grounds of research which they have cultivated with so much success.

But even had the investigations of Messrs. Huggins and Miller been less successful than is the case, they are characterised by a compactness, a precision, an ingenuity, and a tenacity of purpose, which of themselves would have attached and secured the serious consideration of your Council in the award of the Medal. With reference to their colleague Mr. Huggins, your Council feel that any honour bestowed upon him for Astronomical research is in part reflected upon themselves and on the Society at large. With respect to Professor Miller, irrespective of and beyond the inexorable claims of justice which are gladly admitted, they conceive a rare and happy opportunity has arisen for the Astronomical Society to pay the graceful tribute of their hearty sympathy with faithful labourers in fields of science different from their own.

It was on these grounds, then,—the grounds of justice and of sympathy with Science at large, that your Council felt themselves justified in submitting to the Society a proposition for relaxing, on the present occasion, some of those restrictions with which the award of the Medal has hitherto been very wisely surrounded.

The very large majority of the Society who have testified their assent to the course proposed is gratifying to the executive body, while at the same time due honour has been paid to the Laws, by the observance of the formalities required to procure their temporary suspension in a particular case in which was not in the contemplation of those who originally enacted them.

In connexion with the award of our Medal to Messrs. Huggins and Miller for their conjoint labours in Astronomical Physics, it is impossible not to be struck with the vast amount of scientific resource which was of necessity brought to bear upon the processes of the research. The most delicate appliances of optical science, the most refined chemistry, the most profound arrangements of the electric force, have been called into requisition, and, in fact, were essential for the prosecution of the present inquiry. For to-day, then, and for a moment at least, we may perhaps be pardoned the vanity, or it may be even permitted to indulge the loyalty, of regarding the science which we cultivate here, as a Queen, to whom and for whose use her sisters present the tribute of the fruits which they have gathered in the varied fields of human knowledge. Of herself and of her sister sciences no less may be affirmed

than this: the lowliest of them finds a generous home in the ample threshold of her palace, while even the noblest is honoured by sharing a seat upon her throne.

Mr. Huggins and Professor Miller,— I am charged by the Royal Astronomical Society to place in your hands this Medal, which they have awarded to each of you, for your conjoint and important researches in Astronomical Physics.

In presenting this, the highest testimony of our grateful approbation, to you, our colleague, Mr. Huggins, we feel that our Society may claim, and may share, some portion of the distinction which now surrounds yourself.

In presenting it to you, Professor Miller, while we thereby gladly acknowledge a claim of inexorable justice, permit me to add the request that you will convey to the eminent men with whom you are associated, the expression of our hearty sympathy for their labours in their curious fields of scientific research.

You will both of you accept our sincere desire for the continuance of health and energy, enabling you to prosecute fresh researches into the wonderful works of the Great Creator.

APPENDIX.

APPENDIX A.

Chronological Table of the Writers who have taken the principal steps leading to Spectrum Analysis.

(From Dr. W. A. Miller's Lecture. *Pharmaceutical Journal*, Feb. 1862.)

Newton	1701
Wollaston	1802
Fraunhofer	1815

Cosmical lines of solar and stellar spectra.		Absorption bands.		Bright lines of Electric light.		Coloured flames.	
Brewster	1832	Brewster	1832	Wheatstone	1835	Brewster	1822
E. Becquerel	1842	W. H. Miller & Daniell	1833	Foucault	1839	Herschel	1822
Draper	1842			Masson	1851–1855	Fox Talbot	1826
Stokes	1852	W. A. Miller	1845	Angström	1853		1833 & 1834
Brewster Gladstone	1860			Alter	1854–55	W. A. Miller	1845
				Secchi	1855		
				Plücker	1858–60	Swan	1857
				Van der Willigen	1859		

Balfour Stewart 1858 (Law of Exchanges).

Kirchhoff 1859.

Kirchhoff and Bunsen 1860.

APPENDIX B.

List of Authors and their Memoirs since the year 1860.

Stokes. Fluorescence. *Phil. Trans.* 1852 and 1861.

W. A. Miller. Photographic transparency of Various Bodies and Photographic Spectra of the Elements. *Phil. Trans.* 1862.

Donati. Spectra of 15 stars. *Annali del Museo Fiorentino*, 1862.

Astronomer Royal. *Monthly Notices R.A.S.* 1863.

Robinson. On Electric Spectra. *Phil. Trans.* 1863.

A. Mitscherlich. Spectra of compounds &c. *Poggend. Annalen*, 1863 and 1864.

Morren. Phénomènes que présentent quelques flammes. *Annales de Chimie et de Physique*, 1863.

Donati. On Comets. *Monthly Notices R.A.S.* 1863.

Rutherford. Spectra of Stars and Planets. *Silliman's Journal*, vol. xxxv. p. 71.

Heinricks. Distribution of lines in Spectra. *Silliman's Journal*, July 1864 and Nov. 1866.

Chautard. Spectra of rarefied Gases. *Phil. Mag.* November 1864.

Angström. Sur les raies de Fraunhofer. *Les Mondes*, tom. i. p. 10.

Bunsen. Inversion of spectrum of Didymium. *Phil. Mag.*, Sept. 1864.

De La Fontaine. Spectra of Didymium, Erbium, Terbium. *Pogg. Annalen.*

Babinet. Sur la Paragénie. *Cosmos*, October 1864.

Plücker and Hittorf. Spectra of Gases and Vapours. *Phil. Trans.* 1865.

Messrs. Huggins and Miller's works are not here referred to. 1864–66.

Angström. Wave-lengths and Motion of Solar System. *Phil. Mag.* 1865.

Janssen. Spectrum of Aqueous Vapour, *Comptes Rendus*, August 1866.

A. Herschel. Spectra of Meteors. *Intellectual Observer*, October 1866.

Secchi. Many papers in *Astron. Nachrichten, Comptes Rendus, and Monthly Notices.*

Diacon. On the Influence of the Electro-Negative-Elements on the Spectrum of the Metals. *Ann. de Chimie*, IV. Ser. vi. p. 5.

1867. Angström. Atmospheric Lines. *Phil. Mag.*

List of Memoirs by the Medallists.

1. Note on the Lines in the Spectra of some of the Fixed Stars. By Mr. Huggins and Dr. W. A. Miller. *Proceedings Royal Society*, vol. xii. p. 444.

2. On the Spectra of some of the Chemical Elements. By Mr. Huggins. *Phil. Trans.* 1864, pp. 139–160.

3. On the Spectra of some of the Fixed Stars. By Mr. Huggins and Dr. W. A. Miller, *Phil. Trans.* 1864, pp. 413–435.

4. On the Spectra of some of the Nebulæ. By Mr. Huggins. *Phil. Trans.* 1864, pp. 437–444.

5. On the Spectrum of the Great Nebula in the Sword-handle of *Orion*. By Mr. Huggins. *Proceedings Royal Society*, vol. xiv. p. 39.

6. On the Disappearance of Spectrum of ε *Piscium* at its Occultation of Jan. 4, 1865. By Mr. Huggins. *Monthly Notices R.A.S.*, vol. xxv. p. 60.

7. On the Spectrum of Comet I. 1866. By Mr. Huggins. *Proceedings Royal Society*, vol. xv. p. 5.

8. Note on the Spectrum of the Variable Star α *Orionis*. By Mr. Huggins and Dr. W. A. Miller. *Monthly Notices R.A.S.*, vol. xxvi. p. 225.

9. On the Spectrum of a New Star in *Corona Borealis*. By Mr. Huggins and Dr. W. A. Miller. *Proceedings Royal Society*, vol. xv. p. 146.

10. Further Observations on the Spectra of some of the Nebulæ, with a Mode of Determining the Brightness of these Bodies. By Mr. Huggins. *Phil. Trans.* 1866, pp. 381–397.

Appendix C.

The following extracts taken from the Report of the British Association for the Advancement of Science for 1861 by Mr. Balfour Stewart, will explain, and it is hoped justify, the remarks made in p. 153 of the Address.

"In connexion with this subject it may not be out of place to introduce the following extract of a letter from Prof. W. Thomson to Prof. Kirchhoff, dated 1860. Prof. Thomson thus writes:—'Professor Stokes mentioned to me at Cambridge some time ago, probably about ten years, that Professor Miller had made an experiment testing to a very high degree of accuracy the agreement of the double dark line D of the solar spectrum with the double bright line constituting the spectrum of the spirit-lamp burning with salt. I remarked that there must be some physical connexion between two agencies presenting so marked a characteristic in common. He assented, and said he believed a mechanical explanation of the cause was to be had on some such principles as the following:—Vapour of sodium must possess by its molecular structure a tendency to vibrate in the periods corresponding to the degrees of refrangibility of the double line D. Hence the presence of sodium in a source of light must tend to originate light of that quality. On the other hand, vapour of sodium in an atmosphere round a source, must have a great tendency to retain in itself, *i.e.*, to absorb and to have its temperature raised by light from the source, of the precise quality in question. In the atmosphere around the Sun, therefore, there must be

present vapour of sodium, which, according to the mechanical explanation thus suggested, being particularly opake for light of that quality, prevents such of it as is emitted from the Sun from penetrating to any considerable distance through the surrounding atmosphere. The test of this theory must be had in ascertaining whether or not vapour of sodium has the special absorbing power anticipated. I have the impression that some Frenchman did make this out by experiment, but I can find no reference on the point."

"The experiment alluded to by Professor Stokes in this conversation was made by M. Foucault, who in July 1849 communicated to the Institute the result of some observations on the voltaic arc formed between charcoal poles. He found, to use his own words, that this arc, placed in the path of a beam of solar light, absorbs the rays D, so that the dark line D of the solar light is considerably strengthened when the two spectra are exactly superposed. When, on the contrary, they jut out one beyond the other, the line D appears darker than usual in the solar light, and stands out bright in the electric spectrum, which allows one easily to judge of their perfect coincidence. Thus the arc, he continues, presents us with a medium which emits the rays D on its own account, and which at the same time absorbs them when they come from another quarter.

"To make the experiment in a manner still more decisive, Foucault projected on the arc the reflected image of one of the charcoal points, which, like all solid bodies in ignition, give no lines; and under these circumstances the line D appeared as in the solar spectrum."

In a paper by Angström * (a translation of which will be found in the *Philosophical Magazine* for May 1855), the author refers to a conjecture by Euler, that a body absorbs all the series of oscillations which it can itself assume; 'and it follows from this,' says Angström, 'that the same body when heated so as to become luminous must emit the precise rays which at ordinary temperatures are absorbed;' after which remarkable conjecture, now amply verified by experiment, he goes on to say, 'I am therefore convinced that the explanation of the dark lines in the solar spectrum embraces that of the luminous lines in the electric spectrum.'

Mr. Balfour Stewart also states in the same Report as follows: —

"We come now to the subject of light; and since radiant light and heat have been shown by Melloni, Forbes, and others to possess very many properties in common, it was of course only natural to suppose that facts analogous to those mentioned should hold also with regard to light. One instance will at once occur in which this analogy is perfect. For, as all opake bodies heated up to the same temperature radiate the same description of heat, so also when their common temperature is still further increased, they acquire a red heat, or a yellow heat, or a white heat simultaneously.

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* Poggendorff's *Annalen*, vol. xciv. p. 141.

"The idea of applying these views to light had occurred independently to Professor Kirchhoff and myself; but, although Kirchhoff slightly preceded me in publication, it will be convenient to defer the mention of his researches till I come to the subject of lines in the spectrum.

"In February 1860, I communicated to the Royal Society of London a paper in which certain properties of radiant light were investigated, similar to those already treated of with respect to heat.

"In this paper it was mentioned that the amount of light radiated by coloured glasses is in proportion to their depth of colour, transparent glass giving out very little light; also that the radiation from red glass has a greenish tint, while that from green glass has a reddish tint.

"It was also noticed that all coloured glasses ultimately lose their colour in the fire as they approach in temperature the coals around them, the explanation being, that while red glass, for instance, gives out a greenish light, it passes red light from the coals behind it, while it absorbs the green, in such a manner that the light which it radiates precisely makes up for that which it absorbs, so that we have virtually a coal radiation coming partly *from* and partly *through* the glass.

"All these facts are comprehended in the statement that in a constant temperature the absorption of a particle is equal to its radiation, and that for every description of light."

Mr. Fox Talbot, in February 1834, communicated to the *Phil. Mag.* the distinction between the Spectra of salts of Lithia and Strontia, and added the following characteristic remark:—"*I hesitate not to say that optical analysis can distinguish the minutest portion of these two substances* [Lithia and Strontia] *from each other with as much certainty, if not more, than any other known method.*"

The Meeting then proceeded to the election of the Officers and Council for the ensuing year, when the following Fellows were elected:—

President:

Rev. Charles Pritchard, M.A. F.R.S.

Vice-Presidents:

G. B. Airy, M.A. F.R.S. Astronomer Royal.
Rev. Professor Challis, M.A. F.R.S.
Warren De La Rue, Esq. F.R.S.
John Russell Hind, Esq., F.R.S., Superintendent of the *Nautical Almanac.*

Treasurer:

Samuel Charles Whitbread, Esq., F.R.S.

Secretaries:

William Huggins, Esq. F.R.S.
Edward J. Stone, Esq. M.A.

Foreign Secretary:

Admiral R. H. Manners.

Council:

J. C. Adams, M.A. F.R.S.
A. Cayley, M.A. F.R.S.
James Glaisher, Esq. F.R.S.
Rev. Frederick Howlett, M.A.
Rev. Robert Main, M.A. F.R.S. Radcliffe Observer.
R. S. Newall, Esq.
Captain William Noble.
J. Norman Lockyer, Esq.
Major-Gen. Shortrede.
William Simms, Esq.
H. J. S. Smith, M.A. F.R.S.
Lieut.-Col. Alexander Strange, F.R.S.

CORRECTION.

At the bottom of page 76, after the words "the rate might be about one each minute," *insert the words* "for the northern half of the heavens."

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MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

Vol. XXVII. *March* 8, 1867. No. 5.

Rev. Charles Pritchard, President, in the Chair.

Alexander Stewart Herschel, Esq., Professor of Astronomy, &c., at the Andersonian University, Glasgow; and
M. McNeal Walker, Esq., 3 Clyde Place, Glasgow,

were balloted for and duly elected Fellows of the Society.

On the Eclipse of August 1868. By Major F. Tennant.

I a short time ago addressed you, calling the attention of the Council to the Total Solar Eclipse which will be visible in India next year. I have now the pleasure of sending the results of the computations which I have made (as I proposed) on this subject, and beg to add a few remarks.

Total eclipses of the Sun are so rare, that when favourable for observations it has become the custom to seek the places where they are to be seen, and the one which is the subject of this letter is exceptionally favourable for those observations which can only be made during the total phase. In this case at the time of conjunction of the Sun and Moon the latter is but 6 hours removed from her perigee, while the former is not very far from apogee; to the large difference of diameters hence arising must be added the augmentation of that of

the Moon due to the altitude which (as the nearest approach of the centres of the Sun and Moon is geocentrically only 2′ 45″) is very high. The result in this case is a totality which in India lasts between 5 minutes and 5 minutes 50 seconds.

In this case the central line enters on the west coast of India in latitude 16° 35′, about 3 miles north of Viziadroog, and crosses the Peninsula, passing near Muktul and Guntoor, and as little north of Masulipatam. The shadow is about 143 miles broad. The northern limit passes close to the town of Sholapoor (which is accessible by rail from Bombay), about 12 miles north of the large city of Hydrabad in the Dukhun, and 18 miles north of Rajamundri, at the head of the Delta of the Godaveri. The southern limit lies 8 miles north of Goa, or 20 south of the station of Belgaum, 20 miles north of Bellary, 24 south of Kurnool, and 17 south of Ongole. It includes thus the stations of Kolapoor, Belgaum, Kurnool, Sikunderabad, Ongole, Guntoor, Masulipatam, and Rajahmundri, besides some smaller ones; the whole course of the Kistna, its Delta and that of the Godaveri, and parts of the valleys of the Bhema and Toongabudra, lie within these limits. Leaving India proper the shadow crosses the Bay of Bengal, includes the North Andaman Island, and then passes through the Mergui Archipelago and the Province of Tenasserim across the Malay Peninsula to the Island of Borneo (including on its way part of the promontory S.W. from Saigon), which it reaches between our colony of Labuan and the Sarawak country, and eventually through Torres Straits. Of this course the west coast of India will be experiencing the S.W. Monsoon. The same state of things exists at the Andaman Islands and on the British side of the Malay Peninsula. The other side is not easily attainable, and I am not aware that there would be any inducement to go to Borneo. The eastern part of the track through India affords, I believe, every chance of fine weather, and I think observers would do well to select that part. I have computed for the whole breadth of the Indian peninsula, the central line, and the limits of totality, and I have transferred these lines to the accompanying map. I have computed also to a first approximation the track of the shadow till it leaves the Malay Peninsula,* and that portion of it from the Andamans to the East has been also laid down on the map. I have computed the times, &c., of the contacts and formulæ for obtaining the times in the neighbourhood of three places in the neighbourhood of the central line. The latitudes and longitudes used have been given, as I find they differ in different authorities accessible to me, but the variations are not very material; and I hope that from these formulæ the times at any place within the limits of totality can be computed with suffi-

* Omitted in Map as printed.

[illegible]

cient accuracy for enabling an observer to be prepared. I have not extended the formulæ to other parts of the line, as I do not, for the reasons I have given, think they will be useful to English observers.

The total eclipse of 1860 settled that the red protuberances which were first prominently noticed in 1842 were attached to the Sun, but we have little further information. It follows as a consequence of this, that they are of enormous size, but we know nothing of their constitution. They appear not to be identical with faculæ, and I believe are not found to be connected with the spots. If, however, we can see them, we now know that their light will furnish some information. We may hope to decide whether they are gaseous or composed of solid particles, whether they shine by their own light or by that of the Sun, and even to gather some information possibly as to their chemical constitution. I think it desirable that this opportunity of making a contribution to our knowledge of the Sun should not be lost. The next favourable eclipse will doubtless find special objects for examination ready, and we should not let the distance alone of the central line make this useless. There are other difficulties, but they can be got over if taken in time. In India, besides the Astronomer at Madras, there are the officers of the Indian Trigonometrical Survey, and a few others who would, I believe, be glad to have this opportunity of adding to our knowledge, but they are scattered and could not leave their stations without the permission of the Government, and obtaining this would be facilitated by a representation to the Secretary of State for India. It will not do to wait. I believe I may safely say that there is hardly any instrumental means in India suitable for the making of these observations. All appliances must be procured from England, and soon enough for the intending observers to become used to them before the precious few minutes when they are to do their work. With every confidence in the zeal of those who cultivate science, I think it is more than can be reasonably expected that they should go to the expense of procuring instruments on the chance of being in a position to use them. It is a case in which I think the Government may well help; and I should hope that by appointing those who are to share in the responsible operations and furnishing adequate instruments, &c., they would ensure (as far as possible) the attainment of a satisfactory result. Without this there would be great risk of failure with men collected from different parts who do not understand each other's ways, and who are furnished with indifferent means. Still something may be done even by volunteers who know that there will be no difficulties in the way of their using such means as they may acquire.

I would suggest that an effort be made to organize at least two parties, each to be complete. One to be stationed

near the sea in the neighbourhood of Masulipatam and Guntoor in such position as may be found best, and the second inland on the central line about 60 miles south of Hydrabad. One or other of these parties would, I think, be certain to obtain observations, and I think both would succeed if the places be judiciously chosen. The primary object in each case should be to examine the protuberances; but to identify them and connect them if possible with appearances ordinarily visible on the Sun they should be photographed more than once during the totality, and the disk of the Sun also for a week on either side of the day of the eclipse.

I trust I have sufficiently called attention to the subject, and said enough to show that immediate attention is necessary if any results are to be obtained, both in preparing the means and selecting the men, and will leave the matter in the hands of the Council. If I can be of any further use either here or in India it will be a pleasure to me.

Total Solar Eclipse August 17, 1868. *Central Line and Limits of Totality in India. 2nd Approximation.*

Greenwich Mean Time.	Northern Limit. Latitude. N.	Northern Limit. Longitude. E.	Central Line. Latitude. N.	Central Line. Longitude. E.	Central Line. Duration of Totality.	Southern Limit. Latitude. N.	Southern Limit. Longi[tude.] E.
h m s	° ′	° ′	° ′	° ′	m s	° ′	° ′
15 55 0	17 36·3	71 57·6	16 33·4	71 54·2	5 4·5	15 33·3	71 51·9
15 57 30	17 37·2	73 28·6	16 34·9	73 25·3	5 11·6	15 33·9	73 21·9
16 0 0	17 36·9	74 56·0	16 34·9	74 52·3	5 18·3	15 33·2	74 47·8
16 2 30	17 35·3	76 19·9	16 33·3	76 15·4	5 23·7	15 31·2	76 9·6
16 5 0	17 32·5	77 40·3	16 30·1	77 34·3	5 29·6	15 27·7	77 27·4
16 7 30	17 28·6	78 56·6	16 26·6	78 50·3	5 35·3	15 23·3	78 42·4
16 10 0	17 23·8	80 11·7	16 20·6	80 2·9	5 40·3	15 17·8	79 54·2
16 12 30	17 17·7	81 23·1	16 14·5	81 13·4	5 45·4	15 11·6	81 3·8
16 15 0	17 10·6	82 31·6	16 7·4	82 21·2	5 49·9	15 4·6	82 10·7

In Latitude 16° 40′ N. Long. 74° 17′ E. (Kolapoor).

The Eclipse commences at $14^h\ 46^m\ 11^s$ G.M.T. = $19^h\ 43^m\ 19^s$ Local Mean Time, and the point of first contact is 77° 40′ W. of the N. point, and 0° 30′ Left of the vertex of the Sun's limb.

The Totality commences at $15^h\ 56^m\ 20^s$ G.M.T. = $20^h\ 53^m\ 28^s$ Local Mean Time, and it ends at $16^h\ 1^m\ 36^s$ G.M.T. = $20^h\ 58^m\ 44^s$ Local M.T.

The Eclipse ends at $17^h\ 22^m\ 4^s$ G.M.T. = $22^h\ 19^m\ 12^s$ Local Mean Time, and the point of last contact is 106° 35′ E. of the N. point, and 174° 38′ to the Right of the vertex of the Sun's limb.

At any place near the above point where the geocentric N. latitude is l and the E. longitude λ, the Greenwich times of the above phases will be found from the following equations: —

First Contact.

$$\begin{cases} \cos \omega_1 = 0{\cdot}05310 - [0{\cdot}25560] \sin l + [9{\cdot}74441] \cos l \cos (98^\circ\ 25'\ 56'' - \lambda) \\ T_1 = 17^h\ 48^m\ 20^s - [3{\cdot}61453] \sin \omega_1 - [3{\cdot}15475] \sin l - [3{\cdot}88264] \cos l \cos (\lambda - 45^\circ\ 24'\ 11'' \end{cases}$$

Middle of Totality.

$$\begin{cases} \cos \omega_0 = -\ 2{\cdot}5753 - [1{\cdot}72186] \sin l + [1{\cdot}26225] \cos l \cos (\lambda - 72^\circ\ 51'\ 58'') \\ T_0 = 17^h\ 42^m\ 27^s - [3{\cdot}32157] \sin l - [3{\cdot}93471] \cos l \cos (\lambda - 27^\circ\ 9'\ 0'') \end{cases}$$

and the Semi-duration of Totality $= [2{\cdot}20037] \sin \omega_0$.

End of Eclipse.

$$\begin{cases} \cos \omega_4 = -0{\cdot}07077 - [0{\cdot}24273] \sin l + [9{\cdot}85757] \cos l \cos (\lambda - 44^\circ\ 57'\ 43'') \\ T_4 = 17^h\ 6^m\ 45^s + [3{\cdot}71850] \sin \omega_4 - [3{\cdot}48465] \sin l - [3{\cdot}97379] \cos l \cos (\lambda - 6^\circ\ 41'\ 16''). \end{cases}$$

In Latitude 16° 31′ N. Long. 77° 35′ E. (Muktul).

The Eclipse commences at $14^h\ 49^m\ 40^s$ G.M.T. $= 20^h\ 0^m\ 0^s$ of Local Mean Time, and the point of First Contact is 76° 44′ W. of the N. point, and 2° 6′ Left of the vertex of the Sun's limb.

The Totality commences at $16^h\ 3^m\ 16^s$ G.M.T. $= 21^h\ 12^m\ 36^s$ Local Mean Time, and it ends at $16^h\ 7^m\ 48^s = 21^h\ 18^m\ 8^s$.

The Eclipse ends at $17^h\ 30^m\ 31^s$ G.M.T. $= 22^h\ 40^m\ 51^s$ Local Mean Time, and the point of last contact is 107° 39′ to E. of the N. point, or 174° 34′ Right of the vertex of the Sun's limb.

Near the above point in Geocentric N. latitude and l and E. longitude λ we shall have :—

First Contact.

$$\begin{cases} \cos \omega_1 = 0{\cdot}02126 - [0{\cdot}25476] \sin l + [9{\cdot}75392] \cos l \cos (95^\circ\ 47'\ 39'' - \lambda) \\ T_1 = 17^h\ 52^m\ 56^s - [3{\cdot}62868] \sin \omega_1 - [3{\cdot}19281] \sin l - [3{\cdot}89569] \cos l \cos (\lambda - 44^\circ\ 17'\ 36'') \end{cases}$$

Middle of Totality.

$$\begin{cases} \cos \omega_0 = -\ 3{\cdot}0906 - [1{\cdot}71404] \sin l + [1{\cdot}27044] \cos l \cos (\lambda - 69^\circ\ 29'\ 45'') \\ T_0 = 17^h\ 42^m\ 50^s - [3{\cdot}36241] \sin l - [3{\cdot}94699] \cos l \cos (\lambda - 25^\circ\ 29'\ 27'') \end{cases}$$

and Semi-duration of Totality $= [2{\cdot}22041] \sin \omega_0$.

End of Eclipse.

$$\begin{cases} \cos \omega_4 = -\ 0{\cdot}04916 - [0{\cdot}23945] \sin l + 9{\cdot}87688 \cos l \cos (\lambda - 40^\circ\ 32'\ 59'') \\ T_4 = 17^h\ 0^m\ 14^s + 3{\cdot}72851 \sin \omega_4 - [3{\cdot}52358] \sin l - [3{\cdot}98066] \cos l \cos (\lambda - 3\ \ 58'\ 0'') \end{cases}$$

In latitude 16° 10′ N. Long. 81° 10′ E. (Masulipatam).

The Eclipse commences at $14^h\ 54^m\ 11^s$ G.M.T. $= 20^h\ 18^m\ 51^s$ Local M.T., and the point of first contact is 75° 34′ W. of the N. point, and 4° 12′ Left of the vertex of the Sun's limb.

The Totality commences at $16^h\ 9^m\ 31^s$ G.M.T. $= 21^h\ 34^m\ 11^s$ Local Mean Time, and ends at $16^h\ 15^m\ 19^s = 21^h\ 39^m\ 59^s$.

The Eclipse ends at $17^h\ 40^m\ 16^s$ G.M.T. $= 23^h\ 4^m\ 56^s$ Local Mean Time, and the point of last contact is 108° 47′ E. of the N. point, and 175° 11′ Right of the vertex of the Sun's limb.

Near this place in Geocentric N. latitude l, and E. longitude λ.

First Contact.

$$\begin{cases} \cos \omega_1 = -\ 0{\cdot}01750 - [0{\cdot}25371] \sin l + [9{\cdot}76658] \cos l \cos (92^\circ\ 32'\ 18'' - \lambda) \\ T_1 = 17^h\ 58^m\ 6^s - [3{\cdot}64464] \sin \omega_1 - [3{\cdot}23849] \sin l - [3{\cdot}91095] \cos l \cos (\lambda - 42^\circ\ 54'\ 0'') \end{cases}$$

Middle of Eclipse.

$$\begin{cases} \cos \omega_0 = -3{\cdot}6099 - [1{\cdot}70562] \sin l + [1{\cdot}28293] \cos l \cos (\lambda - 65^\circ\ 21'\ 54'') \\ T_0 = 17^h\ 42^m\ 6^s - [3{\cdot}40989] \sin l - [3{\cdot}95954] \cos l \cos (\lambda - 23^\circ\ 24'\ 14'' \end{cases}$$

Semi-duration of Totality $= [2{\cdot}24130] \sin \omega$.

Last Contact.

$$\begin{cases} \cos \omega_4 = -0{\cdot}01944 - [0{\cdot}23592] \sin l + [9{\cdot}89559] \cos l \cos (\lambda - 36^\circ\ 18' \\ T_4 = 16^h\ 53^m\ 21^s + [3{\cdot}73564] \sin \omega_4 - [3{\cdot}55759] \sin l - [3{\cdot}98439] \cos l \cos (\lambda \end{cases}$$

Continuation of the Central Line and Limits of Totality acros of Bengal and the Malay Peninsula. 1st Approximati

Greenwich Mean Time.	Northern Limit. Latitude. N.	Northern Limit. Longitude. E.	Central Line. Latitude. N.	Central Line. Longitude. E.	Southern Limit. Latitude. N.	Southern Limit. Longitude. E.	]
h m	° ′	° ′	° ′	° ′	° ′	° ′	
16 20	16 56	83 53	15 54	83 47	14 52	83 38	The Se
16 25	16 38	85 57	15 36	85 49	14 33	85 38	imatio
16 30	16 16	87 55	15 14	87 46	14 12	87 37	shift
16 35	15 51	89 48	14 50	89 38	13 48	89 28	much.
16 40	15 25	91 36	14 23	91 25	13 21	91 14	would
16 45	14 56	93 20	13 55	93 8	12 53	92 57	along
16 50	14 25	95 1	13 24	94 48	12 22	94 36	chiefly
16 55	13 51	96 38	12 51	96 25	11 50	96 12	effect
17 0	13 17	98 14	12 16	98 0	11 15	97 46	change
17 5	12 40	99 47	11 40	99 33	10 39	99 19	
17 10	12 2	101 19	11 1	101 4	10 0	100 49	

On the Spectrum of Mars, with some Remarks on the Co of that Planet. By William Huggins, Esq., F.R.S.

On several occasions during the late opposition of *Ma* made observations of the spectrum of the solar light refle from that planet.

The spectroscope which I employed was the same as of which a description has appeared in my former pape Two instruments were used, one of which is furnished wi

* "On the Spectra of some of the Fixed Stars." *Phil. Trans.* 1864, p. During my prismatic researches I have tried, and used occasionally, se other arrangements for applying the prism to the telescope. Some of instruments are fitted with compound prisms, which give direct visio have not found any apparatus equal in delicacy and in accuracy to that is referred to in the text.

single prism of dense glass, which has a refracting angle of 60°. The other instrument has two similar prisms.

In a paper "On the Spectra of some of the Fixed Stars," by myself and Dr. W. A. Miller, we state that on one occasion several strong lines of absorption were seen in the more refrangible parts of the spectrum of *Mars*.

During the recent more favourable opportunities of viewing *Mars*, I again saw groups of lines in the blue and indigo parts of the spectrum. However, the faintness of this portion of the spectrum, when the slit was made sufficiently narrow for the distinct observation of the lines of Fraunhofer, did not permit me to measure with accuracy the position of the lines which I saw. For this reason I was unable to determine whether these lines are those which occur in this part of the solar spectrum, or whether any of them are new lines due to an absorption which the light suffers by reflection from the planet.

I have confirmed our former observation that several strong lines exist in the red portion of the spectrum. Fraunhofer's C was distinctly seen, and its identity determined by satisfactory measures with the micrometer of the spectrum apparatus. From this line the spectrum, as far as it can be traced towards the less refrangible end, is crossed by dark lines. One strong line was satisfactorily determined by the micrometer to be situated from C, at about one-fourth of the distance from C to B. As a similar line is not found in this position in the solar spectrum, the line in the spectrum of *Mars* may be accepted as an indication of absorption by the planet, and probably by the atmosphere which surrounds it. The other lines in the red may be identical, at least in part, with B and a, and the adjacent lines of the solar spectrum.

On February 14, faint lines were seen on both sides of Fraunhofer's D. The lines on the more refrangible side of D were stronger than the less refrangible lines. These lines occupy positions in the spectrum apparently coincident with groups of lines which make their appearance when the Sun's light traverses the lower strata of the atmosphere, and which are therefore supposed to be produced by the absorption of gases or vapours existing in our atmosphere. The lines in the spectrum of *Mars* probably indicate the existence of similar matter in the planet's atmosphere. I suspected that these lines were most distinct in the light from the margin of the planet's disk, but this observation was to some extent uncertain. That these lines were not produced by the portion of the Earth's atmosphere through which the light of *Mars* had passed was shown by the absence of similar lines in the spectrum of the Moon, which at the time of observation had a smaller altitude than *Mars*.

I observed also the spectra of the darker portions of the planet's disk. The spectrum of the dark zone beneath the Southern Polar spot appeared as a dusky band when compared

with the spectra of the adjoining brighter parts of the planet. This fainter spectrum appeared to possess a uniform depth of shade throughout its length. This observation would indicate that the material which forms the darker parts of the planet's surface, absorbs all the rays of the spectrum equally. These portions should be therefore neutral, or nearly so, in colour.

I do not now regard the ruddy colour of *Mars* to be due to an *elective* absorption, that is an absorption of certain rays only so as to produce dark lines in the spectrum.

Further, it does not appear to be probable that the ruddy tint which distinguishes *Mars* has its origin in the planet's atmosphere, for the light reflected from the polar regions is free from colour, though this light has traversed a longer column of atmosphere than the light from the central parts of the disk. It is in the central parts of the disk that the colour is most marked. If indeed the colour be produced by the planet's atmosphere, it must be referred to peculiar conditions of it which exist only in connexion with particular portions of the planetary surface. The evidence we possess at present appears to support the opinion that the planet's distinctive colour has its origin in the material of which some parts of its surface are composed. Mr. Lockyer's observation that the colour is most intense when the planet's atmosphere is free from clouds obviously admits of an interpretation in accordance with this view.

This opinion appears to receive support from the photometric observations of Seidel and Zöllner, some of the results of which I will briefly state.

These observations show that *Mars* resembles the Moon in the anomalous amount of variation of the light reflected from it, as it increases and decreases in phase; also in the greater brilliancy of the marginal portions of its disk. Further, Zöllner has found that the albedo of *Mars*, that is, the mean reflective power of the different parts of its disk, is not more than about one half greater than that of the lunar surface. Now these optical characters are in accordance with telescopic observation that in the case of *Mars* the light is reflected almost entirely from the true surface of the planet. *Jupiter* and *Saturn*, the light from which has evidently come from an envelope of clouds, are, on the contrary, less bright at the margin than at the central part of the disk. These planets have an albedo, severally, about four and three times greater than that of the Moon.*

The anomalous degradation in brightness of the Moon at the phases on either side of the full, as well as the greater brilliancy of the limb, may be accounted for by the supposition of inequalities on its surface, and also by a partly regular reflective property of its superficial rocks. Zöllner has shown

* *Photometrische Untersuchungen*, von Dr. J. C. Zöllner, Leipzig, 1865.

that if these phenomena be assumed empirically to be due to inequalities, then the angle of mean elevation of these inequalities must be taken as 52°. On the same hypothesis the more rapid changes of *Mars* would require an angle of 76°.*

It appears to be highly probable that the conditions of surface which give rise to these phenomena are common to the Moon and to *Mars*. The considerations referred to in a former paragraph suggest that these superficial conditions represent peculiarities which exist at the true surface of the planet. In this connexion it is of importance to remark that the darker parts of the disk of *Mars* gradually disappear, and the coloured portions lose their distinctive ruddy tint as they approach the limb.

The observations of Sir John Herschel† and Prof. G. Bond‡ give a mean reflective power to the Moon's surface, similar to that from a "grey, weathered sandstone" rock. Zöllner has confirmed this statement. According to him,—

The albedo of the	Moon	= ·1736	of the	incident light.
,,	Mars	= ·2672	,,	,,
,,	Jupiter	= ·6238	,,	,,
,,	Saturn	= ·4981	,,	,,
,,	White Paper	= ·700	,,	,,
,,	White Sandstone	= ·237	,,	,,

From this table it appears that *Mars* takes in for its own use ·7328 of the energy which it receives as light. *Jupiter's* cloudy atmosphere, nearly as brilliant as white paper, rejects more than six-tenths of the light which falls upon it. Therefore, less than four-tenths of the light which this distant planet receives is alone available for the purposes of its economy.

The photographic researches of Mr. De La Rue and others show that the rays of high refrangibility, which are specially powerful in producing chemical action, are similarly affected.§ At present we know nothing of the reflective power of the planets for those rays of slower vibration, which we call heat.

* *Photometrische Untersuchungen*, von Dr. J. C. Zöllner, Leipzig, 1865, pp. 113, 128.

† *Outlines of Astronomy*, p. 272.

‡ "On the Light of the Moon, and *Jupiter*," *Memoirs Amer. Academy*, vol. viii. p. 222. In the same Memoir Prof. G. Bond estimates the albedo of *Jupiter* to be greater than unity. This estimate would require the admission that *Jupiter* shines in part by native light. Ibid. p. 284.

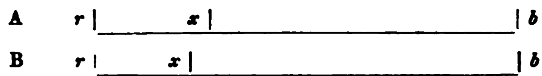
§ Prof. G. Bond states that "the Moon, if the constitution of its surface resembled that of *Jupiter*, would photograph in *one fourteenth* of the time it actually requires." Ibid. p. 223.

Improved Form of Object-Glass, deduced from a Critical Analysis of the Secondary Spectrum. By A. Dawson, Esq.

It has ever since the first discovery of the secondary spectrum been supposed that by using flint and crown glass alone it could never be corrected or avoided. This I have lately found both by theory and experiment to be a mistake; and although at first sight it may appear impossible to alter the proportion of the coloured spaces in the spectrum of the flint glass, yet there is a way of producing this result without in any way interfering either with the constituents of the glass, or with the optical arrangement by the interposition of any extraneous substance whatever.

To make this easily understood it will be needful to present an exact analysis of the secondary spectrum, and this we will now see to.

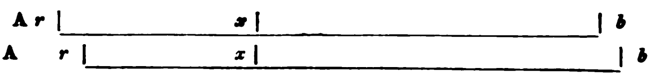
The constitution of the primary spectra then is such



that if A be the spectrum of the crown glass, while B is that of the flint glass, then as they are both coincident at the extremities, the brightest parts x do not coincide.

Now, if an object-glass be made in which the spectra coincide in the above manner, it is clear that although there may be no stray light as arising from the overlapping of the extremities, yet what will be worse will take place, the non-coincidence of the brightest parts of the spectra; thus there will be a secondary spectrum of whitish light and considerable brightness.

But supposing that the flint glass is made a little deeper in its curves, then its spectrum will be placed further out from the axis like this,



and then the brightest x coincides while the extremities overlap, so that the flint glass brings the blue outwards, while the crown glass brings the red inwards, and as these are the dullest parts of the spectra it is much better than when the extremities coincide at the expense of the central parts. This then is the correction always aimed at as producing the greatest clearness in the image, and from the fact that the overlapping red rays have the shortest focus while the blue rays have a long focus, it is said to be "over corrected," though in real fact it is a truer correction than the first case.

It will be needless to refer to the various methods whereby this has been at different times removed, though never yet with permanence; suffice it to say, that until now it has never been accomplished with the ordinary flint and crown glass.

It will appear at once on inspection of the diagrams, that the desired end will be attained if we can by any means cause the blue half of the flint glass spectrum to contract, while the red half is expanded.

This I may as well state at once may be done by refraction.

Suppose, for instance, that the blue rays from the crown glass are made to fall more perpendicularly on the flint glass than the mean, while the red rays are made to fall on it at a lower angle than the mean; it will be clear then that the blue rays will be less refracted, while the red rays will be more refracted, than they otherwise would be.

Now although this seems a difficult condition to fulfil, yet it may be done by *drawing the flint glass to a proper distance behind the crown glass*, when the mean rays will fall on it at a mean angle; but the red rays falling on a part nearer the edge of the flint glass, the refracting surface of that glass will have moved through such a curve as to cause them to fall on it at a lower angle of incidence and so to suffer more refraction; on the other hand, the blue rays being situated nearer the axis they will fall upon the refracting surface of the flint glass with a higher angle of incidence, and so suffer less refraction, the two together conspiring to make the spectrum of the flint glass like that of the crown glass.

Having thus satisfied myself of the principle, it became needful to ascertain how far it could be worked out in practice.

This I tried on a glass of 3½ inches aperture and 5 feet focus, but soon found that the drawing back of the flint glass threw out the focus prodigiously, to avoid which I coupled it with a crown lens which negatived all the refraction of the flint glass, but left a great part of its dispersion. Then after 3 or 4 more alterations I got it so that the secondary spectrum, if not completely corrected, could certainly not be found under any common test.

But that which gave the most conclusive proof of its success must now be detailed.

I had previously bestowed nearly all my study on the figuring of the surfaces of lenses, so that if I wished I could work a surface to such a form, that on the one hand the spherical aberration might be *positive;* and on the other hand the figure might be hyperbolic, making the spherical aberration *negative.*

This then offered a simple and conclusive mode of testing the success of the experiment, for by forming it with the middle and edges polished away so that the spherical aberra-

tion was positive, the expanded disk of a star as seen at the short focus ought to show a bright margin, without any stray light outside this; but if it was made hyperbolic, the same effect ought to take place at the long focus, and still with no stray light outside the expanded disk.

But if there remained any residual secondary spectrum of that kind which obtains in an apparently exactly corrected ordinary achromatic, the expanded disk would at the short focus have appeared as it ought, while that produced by the hyperbolic form at the long focus would have stray light round it; thus by figuring it became easy to distinguish the error produced by the secondary spectrum from that produced by any accidental error in the figure of the lenses.

During the working up then I brought it to these curves successively, and was gratified to find that under each condition it answered exactly as it ought, the question being thereby demonstrated much more satisfactorily and conclusively than any direct observation could do it.

Solar Eclipse of March 6, 1867. By C. L. Prince, Esq.

The weather this morning was very unfavourable for observing this eclipse. At 19^{h} L.S.T. the sky was obscured by large masses of flocculent cumuli and small masses of cumulo strata, the latter at a high elevation, presenting a very peculiar appearance not unlike distant snow-storms. It was not until 19^{h} 16^{m} that I first caught a glimpse of the Sun through my 12-feet Equatoreal of 7 inches aperture. The Moon had by that time considerably advanced upon the solar disk. I had decided upon using the lowest power (120) of my Dawes' solar eye-piece, but I found the atmosphere in such a disturbed, tremulous state that I could not satisfactorily use it. I therefore contracted the aperture to 4 inches and made use of a very low power (30), shaded by a neutral tinted glass, which gives a large field of rather more than one degree, and beautiful definition. From 19^{h} 20^{m} to 19^{h} 39^{m} the clouds were so dense that I could discern the Sun, at intervals only, through them. After this time the Sun shone almost brightly for the space of half an hour. At 19^{h} 42^{m} 47^{s} I observed a remarkable stream of magenta-coloured light pass suddenly along the whole of the preceding edge of the Moon's disk *from* south *to* north. This appearance was as though a large brush of paint had been quickly dashed upon it. The same tint appeared again slightly (but along the whole preceding limb of the Moon simultaneously) at $1^{h}9$ 14^{m} for 10 seconds, slightly again at 19^{h} 54^{m} 13^{s}, and at

$19^h\ 57^m\ 4^s$ for 6 seconds. At $19^h\ 58^m$ a very silvery line of light skirted the preceding limb, and at $19^h\ 59^m$ the magenta tints again appeared for 4^s or 5^s on the northern half of the limb *only*, and obliterated the white line just mentioned. This silvery line was most conspicuous from $20^h\ 1^m$ to $20^h\ 5^m$. At $20^h\ 10^m$ the coloured tints appeared slightly once more, but confined to the northern portion of the Moon's limb. This last appearance continued not more than 4^s. On each occasion the appearance and disappearance of these coloured tints were very rapid, never exceeding one second. At the time of greatest obscuration the Sun could be faintly seen through clouds, and I noticed a conspicuous mountain in N.W., as there were two in S.E. at an earlier period of the eclipse. From $20^h\ 40^m$ the Sun was entirely obscured by clouds until after the time of last contact.

My Observatory is 24″ E. of Greenwich.

Uckfield, Sussex, March 7, 1867.

Eclipse of the Sun, observed on Wednesday, March 6, 1867, at Forest Lodge, Maresfield, Sussex. By Captain W. Noble.

The morning sky was nearly covered with cumuli and strata, so that the instant of first contact was not observed; but, the clouds drifting off a few seconds afterwards, a perceptible indentation in the Sun's limb was visible at $19^h\ 11^m\ 22^s$ L.S.T. $= 20^h\ 16^m\ 58^s$ L.M.T. As the Moon's limb advanced, the clouds cleared away, and then the atmospheric tremor was very great. Despite the bubbling and boiling, the inequalities on the lunar limb were well seen, one high mountain being very conspicuous. At the time of greatest obscuration the landscape presented an appearance analogous to that exhibited before a thunder-storm. About $21^h\ 10^m$ L.S.T. $= 22^h\ 15^m\ 21^s$ L.M.T. I could trace the Moon's limb for one or two minutes of arc beyond the cusps of the Sun; the contrast between its jet blackness and the blue of the sky being very apparent. I had, about the same time, an impression that I could see the southern part of the lunar limb for a considerably greater distance, and that it was relieved against an excessively faint halo, but this may have been an optical illusion.

The moment of last contact was very well observed. A mountain on the Moon's limb—the last visible projection—quitting the solar limb sharply at $21^h\ 46^m\ 39^s{\cdot}1$ L.S.T. $= 22^h\ 51^m\ 50^s{\cdot}24$ L.M.T. This is probably correct within 0·5 seconds.

Not a trace of a spot was visible upon the Sun's disk. I observed with my Ross Equatoreal of 4·2 inches aperture and 61 inches focal length; but with the aperture contracted to 2·8 inches by means of a diaphragm. For the observations of time &c., I used a direct Huyghenian eye-piece, magnifying 74 times, it had a dark blue shade over it. I watched the progress of the eclipse with the same eye-piece fitted into a Hodgson reflector, and also with a direct comet eye-piece, giving a power of 42 with the same eye-shade. I saw, however, nothing worthy of note but what I have detailed above. My approximate latitude and longitude are $51^\circ\ 0'\ 58''$ N. and $17^s\!\cdot\!5$ E.

Forest Lodge, Maresfield, Sussex,
March 8, 1867.

Observations of Solar Eclipse of March 6, 1867.
By W. Lassell, Esq.

But very little could be observed here of the late Solar Eclipse. At its commencement the Sun was unclouded, and I obtained an excellent observation of the first contact, which occurred 1867, March 5th, at $20^h\ 17^m\ 9^s\!\cdot\!5$ G.M.T. Both the error of the clock and the moment of contact were so well determined, that if the errors of both were to lie the same way, I think the observation would be true to a second. The telescope used is a Gregorian of 4·7 in. aperture and the power applied 78. The Sun's limb was by no means quiet, and within a very few minutes clouds came on. About the time of greatest obscuration, a few minute particles of snow fell. The clouds became somewhat thinner towards the close of the eclipse, and I saw the Sun in a very disturbed state within two or three minutes of the time of last contact; but it was quite obscured at the moment by a shower of snow.

The thermometer, in a north aspect and completely defended from the Sun's direct and reflected rays scarcely fell at all—certainly not half a degree.

Latitude $51^\circ\ 31'\ 23''$ N. Longitude $2'\ 49''\!\cdot\!3$ West of Greenwich.

Ray Lodge, Maidenhead,
March 8, 1867.

Observations of Eclipse of March 6, 1867, *with Photographs.*
By A. Brothers, Esq.

At one of the meetings of the Society last year I had the honour to exhibit and explain a dark slide adapted for

taking astronomical photographs, and I suggested that by using such an instrument it would be possible to take a much larger number of negatives during an eclipse of the Sun, than had hitherto been obtained; and that it would be particularly useful during the total phase.

I now have the pleasure to send with this 5 prints,* each containing 4 photographs of the Sun, and I wish to direct particular attention to Plate No. 3. This was taken at $9^h\ 32^m$, about the time of greatest obscuration. The time occupied in obtaining the 4 negatives on this plate was 30 seconds—No. 4 occupied 25, and No. 5 only 20 seconds. It was not of course *necessary* to be thus expeditious, but my object was to show that 4 negatives could be taken on one plate in a very short time, and that with proper care each image of the Sun would be as perfect as if only one had been taken.

If much larger negatives were required, my plan would be equally practicable, although perhaps a few seconds more might be required to make the necessary changes in the position of the plate.

The negatives on Nos. 1 and 5 were taken with the aperture of the telescope cut down to two inches, and all the others with a diaphragm of half an inch only; and the exposure was for each of the 20 negatives as short as it could be made by hand. Nos. 1 and 2 must be considered as trial plates only, as no more than the five were exposed.

During the whole time of the eclipse the sky at Manchester was very clear; and considering the low altitude of the Sun, the image was remarkably shady.

At 9·30 the diminution of light was remarkable only as producing the effect of cloudiness of the atmosphere, and persons who were not aware of the eclipse attributed the effect to the presence of cloud. At 11 o'clock the sky was completely overcast.

Below are the times of the first and last contact as taken at my Observatory.

Partial eclipse of the Sun, 6th March, 1867, observed at 110 Upper Brook Street, Manchester.

Lat. 53° 27′ 56″ N. — Long. $0^h\ 8^m\ 54^s{\cdot}38$

	h	m	s
Local sidereal time of first contact	19	5	45
,, of last contact	21	36	15
	h	m	s
G.M. time of first contact	8	20	15·4
,, of last contact	10	50	20·7

Sidereal time corrected by transit of α Cygni.

* These prints were exhibited at the Meeting. *Ed.*

Manchester, March 7, 1867.

Observations of the Solar Eclipse, March 6, 1867.

(*Communicated by Lord Wrottesley.*)

Observations by Mr. Hough, with the 11-foot Equatoreal:

First contact	$20^{h}\ 9^{m}\ 27^{s}{\cdot}05$	Wrottesley M.T.
End	$22\ 40\ 44{\cdot}12$	

Observations of First Contact by Lord Wrottesley, with a 46-inch achromatic telescope. Both Sun and Moon quite free from tremours.

First contact $20^{h}\ 9^{m}\ 28^{s}{\cdot}94$ Wrottesley M.T.

The end could not be observed with any accuracy with this telescope, as the wind rose before the termination of the Eclipse, and shook the telescope, which was in an exposed situation, violently. The time registered was $22^{h}\ 40^{m}\ 33^{s}$ Wrottesley M.T.

Wrottesley Observatory,
March 6, 1867.

On the Eclipse of March 6, 1867, and a contrivance for viewing the Sun. By John Browning, F.R.A.S.

This eclipse of the Sun was unfortunately rendered invisible by clouds during the greater part of the time, particularly during the interval which corresponded with the *maximum* of the Sun's obscuration. Although from this cause very little could be done, yet some features were noticed which may be worth recording.

I observed the eclipse with Mr. Barnes at his Observatory in Upper Holloway, through an equatoreal reflecting telescope furnished with a silvered glass mirror of $8\frac{1}{2}$ inches diameter. The light and heat of the Sun being of course unbearable in this aperture, the instrument was provided with an arrangement for modifying them, which was, I believe, for the first time applied to a reflector. This contrivance, which I propose to call a *Solar Plane*, consisted of a disk of glass rather more than $\frac{1}{4}$ of an inch thick, mounted in a strong cell and placed on the upper end of the telescope. The glass has plane and parallel sides. On one of the sides of this disk of glass was deposited an exceedingly thin film of pure silver by Liebig's process. This delicate metallic film being turned outwards, having a highly polished surface, reflected nearly the whole of the heat and the greater portion of the light of the Sun's rays, its transparency however being sufficient to enable enough light to pass through it into the telescope to render very small markings on the Sun's surface plainly discernible.

A few days before the eclipse I saw with the assistance of this silvered glass disk three very minute and faint markings, arranged in the form of a triangle on the solar surface. In one of these minute spots the umbra and penumbra could be distinguished.

The body of the Sun seen through the silver film appears of a very cool neutral tint, a colour well adapted for bringing out markings on its surface.

The silvered glass plate I have described is a modification of Foucault's plan of silvering the outer surface of an object-glass, but it avoids the disadvantage of rendering a valuable object-glass useless for any other purpose so long as it is required for solar observations. I think the contrivance far better than a single reflecting prism, or any arrangement adapted to the eye-piece for use with *reflectors*, because it guards the Sun's heat from the telescope, for if the Sun's rays enter the open mouth of the reflector, in a very short time tube currents are set up which almost entirely destroy definition.

When observing the eclipse with the Solar Plane, the first contact of the Moon with the Sun's limb could be scarcely seen for clouds, but at 8^h 20^m the profile of the Moon was plainly seen on the Sun, upon which its continuous encroachment until 8^h 55^m was perceptible.

The mountains on the dark margin of the Moon were beautifully projected upon the luminous disk behind, the protuberances on the S.E. side of the Moon being the most prominent. From the amount of boiling on the edge of the Moon, I regret that I could not draw the form of the protuberances accurately. I have marked in a diagram* the position approximately of the principal mountain, and at the side I have drawn the form of this prominence on a much larger scale. A careful calculation of the exact position of the Moon during her passage across the Sun would, I believe, render the identification of this mountain possible.

From 8^h 55^m to 10^h 11^m the Sun was totally obscured by a mass of dark clouds.

From the readings of a very sensitive thermometer taken during the eclipse, it appeared that the *minimum* temperature was not attained until half an hour after the *maximum* of the eclipse.

I noticed the same result when taking some readings during the eclipse of 1858, when the Sun was also obscured by clouds. Of course the change of temperature during the eclipse was not so great in either case as it would have been, had the sky been cloudless.

At 10^h 40^m the Sun once more became invisible through some rifts in the clouds.

* The diagram referred to and some other diagrams accompanied the original paper.— Ed.

The profile of the Moon, with a comparatively smooth outline, was now seen passing off from the Sun's disk.

It is known to most observers, that when viewing the heavenly bodies the focus of a telescope is altered by the passage of any considerable amount of mist between the object and the observer. While altering the position of the eye-piece to suit the rapidly changing conditions under which I was observing, I noticed that the flying clouds appeared to have a somewhat granular texture. Bringing the eye-piece much more so as to focus the telescope upon the clouds, I became aware that a tremendous snow-storm was going on in the upper regions of our atmosphere.

The telescope I was using cannot be brought to focus upon any object at a less distance than from 500 to 600 yards, and I should judge as it focussed distinctly on the particles of snow, at some distance shorter than the full length of the focussing tube, that the snow I was looking at must have been nearly half a mile high. The motion being of course magnified by the power of the telescope,* snow-flakes passing horizontally across the field of view in front of the Sun at an enormous velocity, presented a most curious spectacle.

As this occurrence took place during the eclipse, and so shortly after the minimum temperature had been noted on the Earth, I think it quite possible that the interception of the solar rays was the cause of the phenomenon.

To unassisted vision the snow presented only the appearance of a slight fleecy cloud, slightly dimming the Sun.

Upper Holloway, March 8.

On the Measurement of the Apparent Disks of Stars. By G. Knott.

(*Additions to a Paper in the Monthly Notice for January last, p.* 87.)

The agreement with theory, though generally satisfactory, is not exact, owing to the fact that the apparent disk has no measurable boundary. It has been shown by the Astronomer Royal, in his treatise "On the Undulatory Theory of Optics," that if e be the radius of the aperture of a telescope in inches, the extreme diameter of a star disk in seconds, to the first black ring, will be $\frac{2 \cdot 76}{e}$. In the annexed table I have given, for the telescope apertures employed in the preceding observations, the theoretical disk diameters calculated in accordance with this formula, and have added in a separate column the corresponding observed diameters resulting from

the mean of all the measures with the exception of those of the small component of the double star *β Cygni.*

Aperture of Telescope.	Diam. of Disk calculated.	Diam. of Disk observed.
in.	in.	in.
7·33	0·752	0·693
6·00	0·920	0·870
4·95	1·113	1·120
4·00	1·380	1·437
3·00	1·840	1·862
2·00	2·760	2·572

It will be seen that with the exception of the measures with apertures 4·95, 4·0, and 3·0 inches, which are slightly in excess, the observed diameter is less than the calculated diameter, a result which for the reason given above we might be naturally led to expect.

Woodcroft Observatory, Cuckfield,
January 9, 1867.

Observations of Iris and Vesta made at Dunsink at the Observatory of Trinity College, Dublin. By F. Brunnow, Astronomer Royal for Ireland.

The hope which I expressed in my last communication, that the Ephemeris of *Iris* computed from my tables would give the place of the planet with great accuracy, has been fully realised. I have obtained here the following Meridian observations :—

		Dunsink M.T.	R.A.	Decl.
		h m s	h m s	° ′ ″
1866	Nov. 23	12 44 5·3	4 55 10·03	+24 56 20·8
	25	12 34 20·4	4 53 16·57	24 43 59·5
	28	12 19 36·9	4 50 20·26	24 24 47·5
	30	12 9 45·3	4 48 20·14	24 11 39·2
	Dec. 5	11 45 5·1	4 43 18·50	23 37 53·6
	10	11 20 26·3	4 38 27·39	23 3 36·3
	12	11 10 53·2	4 36 37·09	22 50 0·5
	14	11 1 16·8	4 34 52·17	22 36 36·7

The error of the Ephemeris according to these observations is,—

	s	"
Nov. 23	−0·22	−0·2
25	0·25	+0·4
28	0·20	+2·0
30	0·11	+1·0
Dec. 5	0·16	−0·1
10	0·21	+2·2
12	0·04	+2·8
14	0·33	+1·3

The mean of these errors is $-0''\cdot19$ in Right Ascension, and $+1''\cdot2$ in Declination, and therefore less than some of the residual errors of the normal places which have been used for determining the elliptic elements. As the planet was very near the Earth at this last opposition, I trust that my tables will give its place with sufficient accuracy for a long time to come.

I also obtained a few observations of *Vesta* :—

	h m s	R.A. h m s	Decl. ° ′ ″
1866 Aug. 25	12 40 8·8	22 56 22·95	− 17 34 52·4
Sept. 2	12 1 27·4	22 49 7·61	− 18 35 11·0

which give the following errors of the Ephemeris in the Berlin *Jahrbuch* :

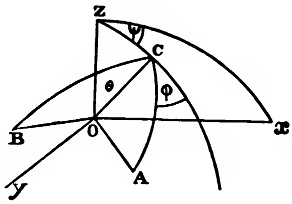
Aug. 25	+ 3·61	+ 30·3
Sept. 2	3·92	32·5

These errors, being unusually large, led me to suspect that the Ephemeris which had been computed from my manuscript tables by Dr. Powalky of Berlin was wrong. I therefore computed the place for August 25 myself, and found indeed an error in the Ephemeris of the *Jahrbuch* amounting to $-0''\cdot71$ and $-10''\cdot0$. This correction will decrease the errors given above, but the remaining error is still larger than I expected. It may be, however, that the effect of the terms of the second order which have been neglected in constructing the tables begins to show itself.

On the Possibility of a Change in the Position of the Earth's Axis due to Frictional Action connected with the Phenomena of the Tides. By E. J. Stone, Esq.

I shall first consider that the frictional action is equivalent to a couple whose intensity is proportional to the existing

angular velocity, and whose axis coincides with the instantaneous axis.



Let O be the centre of gravity of the spheroidal Earth; Ox, Oy, Oz, rectangular axes fixed in space; OC, OA, OB, principal axes; $\omega_3, \omega_1, \omega_2$, the angular velocities about these axes; θ, ψ, and ϕ, the angles which define their position in space at the time t; C, A, A, the moments of inertia of the spheroid about the same principal axes; $-\mu\,\Omega$, the moment of the couple of resistance about the instantaneous axis.

The equations of motion are

$$A\,\frac{d\omega_1}{dt} + (C - A)\,\omega_2\,\omega_3 = -\mu\,\omega_1 \qquad (1)$$

$$A\,\frac{d\omega_2}{dt} - (C - A)\,\omega_1\,\omega_3 = -\mu\,\omega_2 \qquad (2)$$

$$C\,\frac{d\omega_3}{dt} \qquad = -\mu\,\omega_3 \qquad (3)$$

I shall write n for $\frac{C - A}{A}$; p for $\frac{\mu}{A}$; q for $\frac{\mu}{C}$.

From (3),

$$\omega_3 = \gamma\,\epsilon^{-qt}.$$

From (1) and (2),

$$\frac{\omega_1\,d\omega_1 + \omega_2\,d\omega_2}{\omega_1^2 + \omega_2^2} = -p\,dt,$$

or

$$\omega_1^2 + \omega_2^2 = a^2\,\epsilon^{-2pt}.$$

Substituting in (1) we obtain

$$\frac{d\omega_1}{dt} + n\gamma\epsilon^{-qt}\sqrt{a^2\epsilon^{-2pt} - \omega_1^2} = -p\,\omega_1$$

$$\frac{d(\omega_1\epsilon^{pt})}{dt} + n\gamma\epsilon^{-qt}\sqrt{a^2 - (\omega_1\epsilon^{pt})^2} = 0$$

$$\frac{d(\omega_1\epsilon^{pt})}{\sqrt{a^2 - (\omega_1\epsilon^{pt})^2}} + n\gamma\epsilon^{-qt}\,.\,dt = 0$$

$$\cos^{-1}\frac{\omega_1}{\alpha}\epsilon^{pt} = \mathrm{P} - n\frac{\gamma}{q}\epsilon^{-q}$$

$$\omega_1 = \alpha\epsilon^{-pt}\cos\left(\mathrm{P} - n\frac{\gamma}{q}\epsilon^{-qt}\right) \qquad (4)$$

Similarly

$$\omega_2 = \alpha\epsilon^{-pt}\sin\left(\mathrm{P} - n\frac{\gamma}{q}\epsilon^{-qt}\right) \qquad (5)$$

and

$$\omega_3 = \gamma\epsilon^{-qt} \qquad (6)$$

$$\Omega^2 = \omega_1^2 + \omega_2^2 + \omega_3^2 = \gamma^2\epsilon^{-2qt} + \alpha^2\epsilon^{-2pt}.$$

If λ is the angle between the polar axis of figure and the axis of rotation at time t, we have

$$\cos\lambda = \frac{\omega_3}{\Omega} = \frac{\gamma\epsilon^{-qt}}{\sqrt{\gamma^2\epsilon^{-2qt} + \alpha^2\epsilon^{-2pt}}}$$

that is

$$\cos\lambda = \frac{1}{\sqrt{1 + \frac{\alpha^2}{\gamma^2}\epsilon^{-2(p-q)t}}}$$

$$\text{or} \qquad \tan\lambda = \frac{\alpha}{\gamma}\epsilon^{-(p-q)t} \qquad (7)$$

Now $p-q$ is positive, and therefore as t increases positively $\tan\lambda$ becomes more and more nearly equal to zero. Consequently, if our spheroid was at any time rotating about an axis not coincident with a principal axis, it would ever tend to a rotation about the least axis of figure, and after the lapse of ages would be found rotating about an axis but slightly inclined to the least axis of figure. It would appear, therefore, that in this case a near coincidence of the axis of rotation and axis of figure would not in itself be a proof that such near coincidence had always held.

The equations for the determination of the motion of the axes are

$$\frac{d\psi}{dt}\sin\theta = -\omega_1\cos\varphi + \omega_2\sin\varphi \qquad (8)$$

$$\frac{d\theta}{dt} = \omega_1\sin\varphi + \omega_2\cos\varphi \qquad (9)$$

$$\frac{d\varphi}{dt} + \frac{d\psi}{dt}\cos\theta = \omega_3 \qquad (10)$$

Hence

$$\left(\frac{d\theta}{dt}\right)^2 + \left(\frac{d\psi}{dt}\right)^2 \sin^2\theta = \omega_1^2 + \omega_2^2 = \alpha^2\,\iota^{-2pt} \qquad (11)$$

Differentiating (9) we obtain the following equation for the determination of θ:—

$$\left(\frac{d^2\theta}{dt^2} + p\frac{d\theta}{dt}\right)\iota^{2pt} + \frac{C}{A}\gamma^2\iota^{(p-q)t}\sqrt{\alpha^2 - \left(\frac{d\theta}{dt}\iota^{pt}\right)^2} - \cot\theta\left(\alpha^2 - \left(\frac{d\theta}{dt}\iota^{pt}\right)^2\right) = 0$$

$$(12)$$

The value of θ is complicated by the diurnal rotation, and I am unable to obtain the complete integral of this equation. If v is the cosine of the angle between Oz and the instantaneous axis at time t, then

$$v\sqrt{\alpha^2\iota^{-2pt} + \gamma^2\iota^{-2qt}} = \omega_3\cos\theta - \omega_1\sin\theta\,.\cos\varphi + \omega_2\sin\theta\,.\sin\varphi$$

or

$$v\sqrt{\alpha^2\iota^{-2pt} + \gamma^2\iota^{-2qt}} = \gamma\iota^{-qt}\cos\theta + \sin^2\theta\frac{d\psi}{dt}$$

$$= \gamma\iota^{-qt}\cos\theta + \sin\theta\sqrt{\alpha^2\iota^{-2pt} - \left(\frac{d\theta}{dt}\right)^2}$$

Therefore

$$v\sqrt{\alpha^2 + \gamma^2\iota^{2xt}} = \gamma\iota^{xt}\cos\theta + \sin\theta\sqrt{\alpha^2 - \left(\frac{d\theta}{dt}\iota^{pt}\right)^2} \qquad (13)$$

where

$$x = p - q.$$

Differentiating (13) and availing ourselves of (12), we find

$$\frac{d}{dt}(v)\,.\sqrt{\alpha^2 + \gamma^2\iota^{2xt}} + \frac{v\,.\,\gamma\iota^{2xt}x}{\sqrt{\alpha^2 + \gamma^2\iota^{2xt}}} = \gamma x\iota^{xt}\left\{\cos\theta + \frac{\sin\theta}{q}\frac{d\theta}{dt}\right\} \qquad (14)$$

Now

$$\cos\theta = v\cos\lambda + \sqrt{1 - v^2}\,.\sin\lambda\,.\cos ZIP;$$

but $\cos\lambda$ and $\sin\lambda$ contain no periodic terms; v changes with extreme slowness; ZIP changes from o to 2π, at the present time in 24^h. Hence we here neglect the last term and take

$$\cos\theta = v\cos\lambda = \frac{v}{\sqrt{1 + \frac{\alpha^2}{\gamma^2}\iota^{-2xt}}}$$

whence

$$-\sin\theta\,\frac{d\theta}{dt}=\frac{dv}{dt}\cdot\frac{1}{\sqrt{1+\frac{\alpha^2}{\gamma^2}\epsilon^{-2xt}}}+\frac{v\cdot\frac{\alpha^2}{\gamma^2}\epsilon^{-2xt}x}{\left(1+\frac{\alpha^2}{\gamma^2}\epsilon^{-2xt}\right)^{\frac{3}{2}}}$$

Therefore (14) becomes

$$\frac{dv}{dt}\sqrt{1+\frac{\alpha^2}{\gamma^2}\epsilon^{-2xt}}+\frac{vx}{\sqrt{1+\frac{\alpha^2}{\gamma^2}\epsilon^{-2xt}}}=x\left\{\begin{array}{l}\dfrac{v}{\sqrt{1+\frac{\alpha^2}{\gamma^2}\epsilon^{-2xt}}}-\dfrac{\frac{v}{q}\frac{\alpha^2}{\gamma^2}x\epsilon^{-2xt}}{\left(1+\frac{\alpha^2}{\gamma^2}\epsilon^{-2xt}\right)^{\frac{3}{2}}}\\[2ex]-\dfrac{1}{q}\dfrac{dv}{dt}\cdot\dfrac{1}{\sqrt{1+\frac{\alpha^2}{\gamma^2}\epsilon^{-2xt}}}\end{array}\right.$$

$$\therefore\ \frac{dv}{dt}\left\{\left(1+\frac{\alpha^2}{\gamma^2}\epsilon^{-2xt}\right)+\frac{x}{q}\right\}=\frac{-\frac{x}{q}\,v\cdot\frac{\alpha^2}{\gamma^2}\epsilon^{-2xt}x}{1+\frac{\alpha^2}{\gamma^2}\epsilon^{-2xt}}$$

$$\frac{1}{v}\,\frac{dv}{dt}=\frac{1}{2}\left\{\frac{d\tau}{\left(\tau+\frac{x}{2q}\right)-\frac{x}{2q}}-\frac{d\tau}{\left(\tau+\frac{x}{2q}\right)+\frac{x}{2q}}\right\}$$

where

$$\tau=1+\frac{\alpha^2}{\gamma^2}\epsilon^{-2xt}$$

$$\therefore\ \text{Log}\,\frac{v}{A}=\frac{1}{2}\,\text{Log}\,\frac{1+\frac{\alpha^2}{\gamma^2}\epsilon^{-2xt}}{1+\frac{\alpha^2}{\gamma^2}\epsilon^{-2xt}+\frac{x}{q}}$$

$$v=\frac{A\sqrt{1+\frac{\alpha^2}{\gamma^2}\epsilon^{-2xt}}}{1+\frac{\alpha^2}{\gamma^2}\epsilon^{-2xt}+\frac{x}{q}}$$

Determining A so that $v=\dfrac{\gamma}{\sqrt{\alpha^2+\gamma^2}}$ when $t=0$, we have

$$v=\frac{\frac{\gamma^2}{\alpha^2+\gamma^2}\sqrt{1+\frac{\alpha^2}{\gamma^2}+\frac{x}{q}}\sqrt{1+\frac{\alpha^2}{\gamma^2}\epsilon^{-2xt}}}{1+\frac{\alpha^2}{\gamma^2}\epsilon^{-2xt}+\frac{x}{q}}\qquad(16)$$

Let

$v=\cos\mu$ and $\cos\lambda_0=\dfrac{\gamma}{\sqrt{\alpha^2+\gamma^2}}$ $\quad\tan\lambda_0=\dfrac{\alpha}{\gamma}$

Then we have

$$\tan \lambda = \tan \lambda_0 \cdot \varepsilon^{-xt} \qquad (17)$$

and

$$\cos \mu = \cos \lambda_0 \frac{\sqrt{1 + \frac{C-A}{A} \cdot \cos^2 \lambda_0}}{1 + \frac{C-A}{A} \cdot \cos^2 \lambda} \qquad (18)$$

It appears, therefore, that the instantaneous axis is really subject to secular displacement both in the spheroid and in space. If, however, we reduce these formulæ to numbers, throwing the whole of the outstanding 6″ of the Moon's secular acceleration upon the diminution of the Earth's rotation, it will be found that the secular displacements are on such a scale that it would require thousands of millions of years to produce effects of any magnitude.

If we assume that $\lambda_0 = 6°$, an extreme supposition, and take one million of years as our unit of time, we have

$$\text{Log } q = 5{\cdot}8409759$$

and

$$\frac{C-A}{A} = 0{\cdot}00314578 \text{ nearly.}$$

Then for $t = -1000000 \times$ one million years, we have $\delta\lambda = 3° \, 51'$.

The change in the value of $\delta\mu$ is quite insignificant.

The assumption that the Earth's figure has remained rigidly unchanged during such a period of time is certainly most improbable.

If the figure has been modified by the rotation, then the changes in the position of the axes resulting from the causes here considered would be on a still smaller scale. The secular changes resulting from the hypothesis would appear to be far too slow to produce any important effects even within geological periods.

I shall next suppose that the tidal action may be represented by a couple of resistance with its axis perpendicular to the plane of the ecliptic, and proportional to the relative angular velocity of the Earth and Moon on this plane. This supposition may be approximately true when the angular velocity is much reduced, and the truth must, I think, lie intermediate between the two hypotheses made.

In this case it will be sufficient to consider the Earth a sphere. If O z is the pole of the ecliptic, we have

$$A \frac{d\omega_3}{dt} = -f \{\omega_3 - n\}$$

$$\mathrm{A}\,\frac{d\,\omega_1}{d\,t} = 0. \qquad \mathrm{A}\,\frac{d\,\omega_2}{d\,t} = 0$$

$$\therefore \quad \omega_1 = \omega \cos \alpha \qquad \omega_2 = \omega \cos \beta$$

$$\frac{d\,\omega_3}{d\,t} + \mu\,\omega_3 = +\,\mu\,n$$

where

$$\frac{\;}{\mathrm{A}} = \mu$$

$$\therefore \quad \frac{d}{d\,t}\left(\iota^{\mu t}\,\omega_3\right) = \mu\,n\,\iota^{\mu t}$$

$$\omega_3 = \mathrm{P}\,\iota^{-\mu t} + n$$

$$\omega \cos \gamma = \mathrm{P} + n$$

$$\omega_3 = (\omega \cos \gamma - n)\,\iota^{-\mu t} + n$$

$$\Omega^2 = \omega^2 (\cos^2 \alpha + \cos^2 \beta) + \left\{n + (\omega \cos \gamma - n)\,\iota^{-\mu t}\right\}^2$$

And if λ is the angle between the pole of the axis of rotation and the pole of the ecliptic,

$$\cos \lambda = \frac{(\omega \cos \gamma - n)\,\iota^{-\mu t} + n}{\sqrt{\omega^2 \sin^2 \gamma + \left\{n + \omega\,(\cos \gamma - n)\,\iota^{-\mu t}\right\}^2}}$$

Therefore

$$\cos \lambda = \frac{\frac{n}{\omega} + \left(\cos \gamma - \frac{n}{\omega}\right)\iota^{-\mu t}}{\sqrt{\sin^2 \gamma + \left\{\frac{n}{\omega} + \left(\cos \gamma - \frac{n}{\omega}\right)\iota^{-\mu t}\right\}^2}}.$$

Assuming as before that the whole $6''$ in the secular acceleration of the Moon's mean motion in longitude is due to the change of rotation of the Earth, and taking $\gamma = 23^\circ$, $\frac{n}{\omega} = \frac{1}{28}$, and a million of years as the unit of time, we have

$$\mathrm{Log}\,\mu = 5{\cdot}9301091.$$

The following numbers show the exceeding slowness with which the changes take place:—

For	$t = 0$	$\lambda = 23^\circ$
	$t = 1000$	$\lambda = 25^\circ$
	$t = 10000$	$\lambda = 43^\circ$
	$t = 100000$	$\lambda = 84^\circ\,45'$.

For $t = -100000$ the time of rotation on this hypothesis would be about 20 seconds.

The frictional action of the tides must, I conceive, lie between the two hypotheses made; the first being probably the more accurate for large velocities of rotation. On both suppositions we are led to secular displacements of the axis of rotation, but we cannot be justified in assuming the rigidity of the Earth during such periods as would be required to produce any considerable effects from the cause here considered. On the whole I am of opinion that this cause is not available for an explanation of those secular changes of climate which geologists have shown to have taken place on our Earth.

Observations of the Planet Mars. By John Joynson, Esq.

(*Communicated by John Stanistreet, Esq., F.R.S.*)

The observations of the planet *Mars* that have been made during the last three months have been almost entirely confined to the appearance of his disk. Every care has been taken not to examine the former observations while drawing the present appearances, to ensure as far as possible their being independently obtained, but they have resulted in confirming the former views to the fullest extent.

There can be no doubt whatever that the band is permanent, and that it extends all round the planet, with one, and as far as could be found, only one, narrow break in it. The colour of the band was generally a dark green.

The accompanying drawings are intended as a sequel to those sent in 1865 of the two previous oppositions.*

Waterloo, near Liverpool,
13 *February*, 1867.

On an Astronomical Presentiment of Immanuel Kant relative to the Constancy of the Earth's Sidereal Period of Rotation on its Axis. By A. D. Wackerbarth.

This great man's entire works (*Sämmtliche Werke*) were about a quarter of a century ago published at Leipzig, edited by Messrs. Karl Rosenkranz and Friedrich Wilhelm Schubert. The 6th volume contains his works on Physical Geography (*Schriften zur Physischen Geographie*), and opens with a little paper of 7 octavo pages, the title of which is: "Untersuchung der Frage; Ob die Erde in ihre Umdrehung um die

* These drawings were exhibited at the Meeting.

Achse wodurch sie die Abwechselung des Tages und der Nacht hervorbringt einige Veränderung seit den ersten Zeiten ihres Ursprunges erlitten habe, welches die Ursache davon sey, und woraus man sich ihrer versichern könne? Welche von der Königlichen Akademie der Wissenschaften zu Berlin zum Preise aufgegeben worden, 1754." *

Such a cause he discovers in the motion of the water in the ocean caused by ebb and flood, and though the effect of this may be very small, yet, he observes, as it is for ever and unceasingly in action, a philosopher can never be justified in assuming that it cannot in the lapse of ages become sensible. He then, assuming the water at the equator to have a motion of one foot per second in a direction contrary to that of the Earth's rotation, proceeds to estimate the pressure perpendicular to the plane of a meridian, and thence to deduce the effect of the fluid mass to retard the revolution of the Earth on its axis. His result, it is true, is enormously too great, for he finds that the apparent decrease in the length of the year arising from the real increase in the length of the day would in the course of 2000 years amount to 8½ hours; but however erroneous this result may be, we cannot deny him the credit of having anticipated by a little more than a century (his work was first published in 1754), the hypothesis of M. Delaunay, that the Earth's rotation is sensibly retarded by the effect of the tides.

Meteors observed October 25, 1866, at Freemantle, West Australia. By F. B. Duone, Superintendent of Water Police.

(*Communicated by H. M. Lefroy, Esq.*)

On Thursday the 25th October, at about noon, the weather being very fine but sultry, sky clear, the wind light from S.W., a considerable number of apparently small objects were seen from the water police boat at sea between Freemantle and Rottnest, to pass over head in a direction from S.W. to N.E. I recognised them at once to be meteoric bodies, some were followed by luminous trains, others not so. One very remarkable one, which particularly riveted my attention, appeared a uniformly round body and very like the planet *Venus* when seen by daylight above the period of her greatest elongation. It would be impossible to judge of their height; their rate of motion, I should say, would be about 2°, or four times the diameter of the Moon, in a second. The appearance of all was the same, that of star-like bodies seen by daylight,

* Whether the Earth's diurnal rotation has at any time been exposed to any change, what may be the cause of such change, and how can we be assured of its reality? Prize question proposed by the Royal Academy of Berlin, 1754.

some with, and others without the luminous train; in short, just what I should imagine would be the effect of a meteoric shower seen by daylight in a very clear atmosphere, and under a cloudless sky. The phenomenon was observed for about half an hour, and frequently two or three of the bodies passed at the same time. We had found the heat of the forenoon very oppressive. I may add, that during the whole display the sky was filled with a phosphorescence so strong that it gave considerable light to the Earth. A river at some distance, which in the clearest moonless nights is invisible from here, glistened quite brightly, even when scarce a star was to be seen through the clouds.

Observation of the Meteoric Shower of November 13–14, 1866, at the Observatory of Trinity College, Dublin. By F. Brunnow, Astronomer Royal for Ireland.

The display of the meteors on the night of the 13th of November was seen here in all its splendour, as the night with the exception of short intervals was perfectly clear. Being engaged, however, in other observations, I did not commence to observe the meteors until 12 o'clock, when the great shower had already begun. I was placed at a window facing due east, and the number of meteors in the following table refers only to those visible in that part of the heavens.

Number of Meteors.

h m	m		h m	m	
12 0	— 5	46	13 25	— 30	30
5	10	89	30	35	27
10	15	115	35	40	23
15	20	112	40	45	19
20	25	147	45	50	14
25	30	172	50	55	10
30	35	216	Cloudy		
35	40	248	14 5	10	10
40	45	189	15	20	13
45	50	136	20	25	17
50	55	152	25	30	10
55	0	80	30	35	11
13 0	5	59	35	40	15
5	10	Cloudy	40	45	11
10	15	51	45	50	Cloudy
15	20	44	50	55	10
20	25	32	55	60	9

The error of my watch which is to be applied to those times was

$$+ 8^m\ 12^s{\cdot}9$$

and thus the time of the maximum may be put down as

$$12^h\ 45^m\ 43^s$$

The meteors with very few exceptions seemed to radiate from a point situated on the line joining γ and ι *Leonis*, in which a perpendicular let fall from ζ meets this line. The Right Ascension and Declination of this point is according to Bode's maps; $\alpha = 150°$ and $\delta = +22°$, and for 1866 November, $\alpha = 150° 26'$ and $+21° 41'$.

On the Meteoric Shower of November 13–14, 1866. By W. Masters, Professor at Kishnaghur College, Bengal.

(*Communicated by Sir J. W. F. Herschel, Bart.*)

My attention was first drawn to the November meteors in 1833 (I believe), when a little before sunrise, while seated in an upper verandah in Calcutta, and looking south, I observed white, pearly, flaky, I might almost say tiny spiritual things of the shape of Rupert-drops, falling, as I fancied, perpendicularly down, about a yard or two apart, and about fifteen succeeding each other in two or three minutes, within the range of direct vision. Day followed too quick for this exhibition to last long.

Since that time I had been watching their recurrence year after year without success, and was on the look out for them from the 9th to the 13th inst., when only a few stragglers presented themselves. Up to 11 P.M. of the 13th there was no sign of meteors; but at half-past 4 A.M. of the 14th inst. they were in great abundance over Kishnaghur, in Bengal, about fifty-seven miles due north of Calcutta. I cannot say at what hour they first began to fall, although I have made inquiries of police-watchmen and others. I looked out about half-past four or a quarter to five, and observed them shooting along the sky divergingly and very rapidly from some part of the head of *Leo Major;* and from their manner of comporting themselves was immediately convinced that we had come upon the great shoal of November. I was most interested in detecting if possible the precise point of divergence, and it soon became evident that, contrary to received opinion, γ *Leonis* was not the starting point. After counting fifty in about five minutes, I woke up

four other persons to witness the phenomenon and give aid in watching and counting.

We arranged ourselves looking in different directions, and as each saw a meteor there was a distinct call of the next number, 51, 52, 53, &c.; the stars shooting out sometimes faster than they could be counted. Some were lost on this account; some owing to the excitement of my youthful coadjutors; and many while I was waking up aid. Yet in less than half-an-hour we counted 420; had we been all together during the half-hour we would certainly have counted more than 500.

The velocity of these meteors was exceedingly great; there was no lagging or hesitation in their course, as is frequently the case with ordinary meteors; but they darted like rockets from an unseen centre, sometimes three or four in one direction nearly, slightly diverging, leaving long and short trains with much divergence horizonwards and narrow convergence upwards. I shall call these α for reference in the sequel. Others shot in different directions East, West, North, and South, and intermediate points were filled up in rapid succession; not one appeared to fall perpendicular to the Earth; all described glowing arcs in the sky varying from 20° to 60°, a few points of light excepted which described scarcely 3° or 4°.

Their decided and long courses, all seeking the horizon directly, and their persistent trains of light, which looked like meridians on a globe, strongly and unmistakably pointed to a spot in the head of *Leo Major*, then some degrees eastward of zenith, as their radiating point. To a spectator not anticipating such a phenomenon, the rush of fiery stars from an unseen centre overhead to the horizon all round must have been powerfully astonishing; even the unsurprised spectator was impressed with awe. A mad career of stars shooting across the heavens in varying and interlacing directions might create bewilderment and dread in all beholders; but these, though hurrying swiftly on some important errand, betokened order and law, and filled the mind with feelings of beauty and sublimity.

The meteors did not actually start into view at one point; many commenced their courses about 30° or 40° from the supposed point of divergence, seeking the different points of the horizon, while the upper portion of their trains pointed to the same spot in the sky. These were generally large and bright and illumined the trees and walls like a flash of lightning from a thunder-cloud near the horizon; others, comparatively small, darted or showed themselves only a few degrees from the radiating centre, sometimes three at once, leaving their trains tracing backwards. Those with long trains and long courses generally burst or blazed out about 20° or 30° from the horizon; some within 20° of it. No sound of any kind was heard; the light of these meteors when they blazed out was reddish; the trains behind were generally broad, spreading

about half a degree, glowing at first like the fresh mark of phosphorus on a wall, then quickly becoming pale like the tail of a comet, or like the mingling of muriatic acid gas and ammonia, and lasting from half a minute to one minute and a half.

One took me quite by surprise; it blazed out like a star of the 2nd or 3rd magnitude between ι and μ of *Leo Major*, as bright as ι, but not of the same silveriness or intensity, and gradually faded away in the same spot without any visible linear course whatever; it suggested the idea of a meteor coming straight to the eye.

I looked out again at 6 A.M. before the sun rose, and saw a streak of white light, like a Rupert's-drop with a long thread behind, shoot down from the direction of *Leo Major* to *Capella; Alajoth* in the North-west the only star then visible. The meteor appeared to be close at hand, and looked exactly like those of 1833, with the exception of the long thread. About three or four of the meteors enumerated above did not shoot from the diverging point; if they belonged to the same set they must have been drawn out of their course.

After as careful a survey as the phenomena would permit, I have no doubt that the centre of radiation was somewhere between the two stars in the head of *Leo Major*, viz. ι and μ; and probably at the precise spot where a meteor appeared and disappeared. I saw one meteor start a few degrees North of μ scarcely 3°, to a point between North and North-east, and its course traced backwards passed nearly straight over μ and ι, and the clear impression of the moment on my mind was that a line darted from ι across μ and onward, the line becoming a meteor some distance further on. Again, the set of three or four which I have called α above, shot south-eastward, leaving *Regulus* a l.ttle to the east, starting nearly on a parallel with *Regulus*, their pale traces left in the sky converged unmistakably up to ι and μ as per margin; one trace proceeding a little more north than the other, and the meteor noticed above, which blazed out between these two stars, appears to reveal the true point of divergence. I have put a mark between the two to indicate the spot, nearer to ι than to μ; and were it not for this meteor I should have fixed upon ι as the diverging point. Some point near γ *Leonis* was the diverging point in 1833. If other observers confirm my statement, some step, I imagine, will be gained towards the determination of the orbit of the November shoal.

μ

ι

On the supposition that the meteors are not self-luminous, but become visible after contact with our atmosphere, it would appear that the atmosphere was unpierced by any meteors, two excepted, to a distance of about 10° at most all round ι.

The apex of the Zodiacal light appeared to be some degrees south both of ι and γ *Leonis*.

An "observer" at Sealkote states that he saw meteors from midnight of the 13th to the dawn of the 14th inst.

There is a report that the meteors were seen at Lahore "to clash against each other and mount upwards again."

27th Nov. 1866,
Kishnaghur.

The Meteors of December 12–13, 1866, *as observed at Millbrook, Tuam.* By J. Birmingham, Esq.

Though the December meteors could not be compared to the wondrous display of the previous month, still in scientific interest they may be considered quite equal to their more brilliant precursors; and as I have not seen them noticed by other observers I am the more induced to offer the following brief account of them for the consideration of the Society.

There was great rain for two hours before 9 P.M. on the 12th, when it began to clear, and at $9^h\ 15^m$ I saw a small meteor going south from *Gemini*. Within the next fifteen minutes I observed nine others shown by alignments to radiate from within a circle about 3° in diameter, with its centre in Right Ascension 107° and North Polar Distance 71°. However, a slightly elongated and almost stationary meteor which appeared at the intersection of lines joining β and ι, δ and θ *Geminorum* would seem to indicate a somewhat higher radiant; and, as the night advanced, a few of the meteors proceeded from other places in the neighbourhood of *Gemini*. Regarding the tangent of the Earth's course on the night in question as directed towards 171° of longitude, it will be seen that the December radiant shows an orbit differing widely in relation to our own from that of the November group. Up to $1^h\ 25^m$ on the morning of the 13th I counted 260 meteors diverging to every point in the heavens, but the greater number fell towards the horizon between the south and the north-west. Unlike the full, glowing disks that traversed the sky on the 14th November, the present meteors might be described as having a *cindery* aspect, with, however, some notable exceptions. They were mostly of a bluish white colour; and red was to be found only among those that showed no connexion with the radiating movement, and of which I counted twenty. Though many appeared as trainless sparks, they generally showed tails that differed from those of the November meteors, as they were always of the same colour as the nuclei and left no cloudy traces after their extinction—facts suggestive of the idea that they were merely optical. One that was brighter than *Sirius* passed close to that star, as did another with equal

magnitude and with a serpentine course. There was no well-marked time of maximum display, but there seemed to be alternate periods of repose and activity.

After *Gemini* passed the meridian the sky became overcast; and, though I watched closely for openings in the clouds, I saw nothing until $3^h\ 8^m$, when an immense fire-ball flashed through a misty break in *Leo*, and all again was darkness. Soon after this it partially cleared towards the east, and from time to time I was able to catch sight of a meteor moving in that direction. At about five o'clock there was heavy rain that continued for half-an-hour; and at $5^h\ 53^m$ I remarked one meteor falling from the direction of *Gemini* through *Hydra*. The west and north were still clouded, and I saw no more until *Saturn* appeared enveloped in the breaking day, when I left off observing.

As there were some of those meteors that might be well distinguished from the rest, I was careful to mark their places on a map, hoping that they might, perhaps, be identified by other observers, and have their height determined

The most remarkable appeared as follows:—

G.M.T. 1866, Dec. 12–13. h m	
10 18 P.M.	Close by Procyon, in a line from δ Geminorum; as large as Sirius.
10 53	Through Præsepe, in a line parallel with Castor and Pollux.
11 11	From Procyon, in line produced from direction of β Aurigæ.
11 51	Precisely over g, and between ζ and γ Leonis.
0 11 A.M.	From close below κ Ursæ, across ν.
1 14	Near Sirius, between μ and γ; larger than Sirius.
1 35	From ι, in a curve between η and γ Leonis.
4 30	From Draco, across the Camelopard to the true Pole, in a perpendicular to the Pole and ζ Ursæ Min.
4 36	In Corona, pointing from near δ Böotis to near δ Coronæ.

Place of observation, Lat. 53° 37′ 43″, Long. 8° 53′ (approximate).

On the Compatibility of the Retrograde Orbit of the November Meteors with the Nebular Theory. By John Hippisley, F.R.S.

In the *Monthly Notices* for December 1866, Sir John Herschel, having arrived at the conclusion that the orbital motion of the November meteors is *retrograde*, leaves it to the advocates of the nebular hypothesis to reconcile that fact with their theory.

The nebular hypothesis supposes that space was once,

generally, though not equably, nor homogeneously, filled with matter in a nebulous form. And that the Sun with his planets and satellites, and the fixed stars with their presumable attendants, represent the ultimate result (at least up to the epoch in which we live), of the several aggregations of large volumes of nebulous matter at and around different centres of predominant attraction.

It would seem a necessary consequence of such a supposed distribution, that outlying patches of the nebulous material would remain in the intervening spaces, having no decisive preponderance to any of the more important centres. These portions, though severally insufficient in amount for the formation of a luminous Sun and its planetary system, would nevertheless be subject to the same principles of aggregation, and would in course of time form systems minute, but analogous to those of more importance and splendour. A central body, perhaps not luminous, or soon cooling down to non-luminosity, with rings or planetoid companions.

Such systems might be very numerous, insomuch that the Sun, by reason of his proper motion through space, might frequently approach and annex them to his own system. In the case of direct collision an extraordinary accession of light and heat (such as the recent blaze in *Corona Borealis*, or the remarkable phenomenon seen by Mr. Carrington and another observer in the Sun's photosphere) would signalize the termination of the career of the miniature system at the surface of the Sun. In any other case an orbit, more or less excentric, would be the result, the elliptical proportions of which would be determined by the direction and amount of the relative proper motions of the system and of the Sun at the epoch of annexation. *But it would depend on the accident of the system's approaching from a point to the east or the west* of the Sun's path through space, *whether this orbit should be direct or retrograde*, and its inclination to the plane of the ecliptic would be determined by the place relatively to that plane which the system occupied before annexation.

An orbit originating out of such circumstances would probably be very excentric, as are those of the comets, and of the November meteors, to which, in accordance with the deductions of the Astronomer Royal, we may ascribe a considerable excentricity and inclination.

The velocity of minute planetoids round a small central body would be slow in comparison with the known planetary velocities. And the minute system itself would be invisible from the Earth, except in case of extremely close approach or contact.

Suppose, then, the November meteorites to be not a continuous ring around the Sun, but a ring of planetoids revolving at a slow speed about some small central body ; that this system was not an original member of the solar system ; that

it has been annexed; that its approach to the Sun was from a point to the west of the Sun's path through space; that it now revolves round the Sun in a year nearly; that the distance of this orbit at its node is such that the outer part of this system, namely the ring, reaches to the Earth's orbit, and that the period of the revolution of the ring about the central body is either 33 years or some other period, differing from one year, or other sub-multiple of 33 years by the fraction suitable to the observed periodical recurrence of the concentrated portion of the ring; under these suppositions conditions would be present compatible with the nebular hypothesis, and consistent with the observed retrograde orbit of the meteors. Their real path through space will, it is true, be slightly different from that which a continuous ring around the Sun implies; but as their revolution around their principal may be very slow, their translation through space, as seen from the Earth, will depend chiefly on their orbital motion round the Sun.

An elliptical orbit of any dimensions, provided that the perihelion distance be not greater, and the aphelion distance not less than the semi-diameter of the Earth's orbit, will suffice, in combination with suitable inclination to the plane of the ecliptic, for the condition of a contact with the Earth at one only of the nodes. Probably, however, the area of the meteorite ellipse is not very different from that of the Earth's orbit.

The plane of the meteoric ring, since its revolution (which may be direct or retrograde), around its central body was established before its orbital revolution round the Sun commenced, may be inclined at any angle to the plane of that orbit consistently with the nebular hypothesis.

The retrograde and inclined orbits of comets may be accounted for on like principles, on the supposition that they also have become by similar annexation comparatively recent members of the Solar System.

Stoneaston, January 26, 1867.

Considerations on Sun-Spots. By M. Hoek.

(Extract from a Letter to Mr. De La Rue.)

"J'ai lu avec beaucoup d'intérêt la Note que vous venez d'insérer dans les *Monthly Notices* (vol. xxvii. No. 1), en commun avec MM. Stewart et Loewy. Elle contient des résultats qui m'ont rappelé d'avoir commencé, il y a plus d'une année, une recherche que depuis j'avais abandonnée, sans cependant me souvenir pourquoi. Dans cette recherche théorique mon point de départ a été l'hypothèse que le Soleil est

une masse gazeuse. Je me suis dit qu'alors il était nécessaire qu'il y eût à sa surface des marées produites par l'attraction des planètes, et je me suis demandé si peut-être on y trouverait l'explication de la périodicité des taches solaires.

"En lisant votre Note je me rappelais d'avoir trouvé que les marées dépendant de *Jupiter* et de *Vénus* seraient les principales. Et voilà que votre Note indique précisément les mêmes planètes comme connexes d'une manière quelconque à la production des taches solaires.

"C'est ce qui m'a décidé à chercher ces anciens calculs.

"Peut-être les résultats auront quelque intérêt pour vous, tandis que vous vous occupez de ce genre de recherches. C'est pourquoi je me donne l'honneur de vous les communiquer.

"D'abord, si l'on nomme la masse d'une planète M, sa distance au centre du Soleil a, les marées qu'elle produit à la surface de cet astre seront à très-peu-près proportionnelles à la quantité $\frac{M}{a^3}$.

"On trouve ainsi pour *Mercure, Vénus, La Terre, Mars, Jupiter*, et *Saturne*, des nombres proportionnels à 12, 24, 10, 0, 23, et 1. Les marées qui dépendent de *Vénus* et de *Jupiter* sont donc en général prédominantes, quoiqu'il ne faille pas oublier que *Mercure* dans son périhélie donne 24, dans son aphélie 7.

"Reste à savoir, et c'est le point capital, quelle est la hauteur absolue de ces marées. Voici ce que je trouve dans mes papiers:—

"On peut appliquer ici la formule (16) donnée par M. Roche dans ses *Recherches sur les Atmosphères des Comètes* (*Annales de l'Observatoire de Paris*, tome v.)

"Cette formule donne la relation entre deux rayons de l'équateur solaire dont l'un R′ dirigé sur la planète a une longitude héliocentrique λ, et dont l'autre R″ a une longitude $\lambda + 90$.

"Faisons dans cette formule $R'' = R' - \tau$, nous aurons à des quantités du second ordre près $\left(\frac{R''}{R'}\right)^3 = 1 - 3\frac{\tau}{R'}$, et la formule se réduit à celle-ci:—

$$\frac{\tau}{R'} = \frac{3}{5 - 2\gamma(1+\mu) + 2\mu\left(\frac{a}{R'}\right)^3}$$

où les symboles denotent

τ, la différence de niveau du flux et du reflux;

R′, le rayon de l'équateur solaire;

$\gamma = \frac{T^2}{t^2}$; $\mu = \frac{m}{M}$;

T, la durée de la révolution sidérale de la planète;

t, celle de la rotation du Soleil ;
m, la masse du Soleil ; M, celle de la planète ;
a, la distance de la planète au centre du Soleil.

" On a donc approximativement :

	Pour Jupiter :	Pour Vénus :
μ	$= 1000$	400000
γ	$= (172)^2$	81
$\frac{a}{R}$	$= 570$	80
donc τ	$=$ 0·01 mètres.	0·01 mètres.

quantités tellement insignifiantes qu'elles m'ont décidé à quitter la recherche.

" Avant de vous écrire, j'ai répété ces calculs, et j'ai obtenu les mêmes résultats qu'auparavant.

" Autrefois j'en avais conclu que l'attraction des planètes ne pourrait nullement rendre compte de ces révolutions véhémentes qui s'accomplissent à la surface du Soleil.

" Aujourd'hui je ne suis plus de cet avis, mais j'hésite à me prononcer sur ce point.

" Qu'on se représente des conditions d'équilibre instable, et la moindre force suffit à le rompre et à produire des phénomènes importants. Dans le cas actuel il n'est pas impossible de se représenter de telles circonstances. Les couches extérieures du Soleil, rayonnant leur chaleur dans l'espace, doivent par conséquent devenir plus denses. Il suffit que leur densité surpasse celle des couches situées plus près du centre pour avoir l'équilibre instable. Il viendra un moment où elles iront s'engloutir dans l'intérieur du Soleil pour être remplacées par des couches moins denses.

" Il est donc possible que les marées produites par les planètes, quelque insignifiantes qu'elles soient, suffisent à fixer ce moment. S'il en fut ainsi je présume qu'on verrait les taches solaires naître de préférence dans ces parties de la surface qui ont leur mouvement dirigé vers le centre du soleil et qui ont un maximum de vitessè d'oscillation.

" On trouve sans peine la position de ces parties par rapport à la planète perturbante.

" En effet, faisons dans la formule (6) de M. Roche $\delta = 90^\circ$, pour ne nous occuper que de l'équateur solaire, et differentions par rapport à r et ψ, nous aurons :

$$\frac{\partial r}{\partial \psi} = \frac{3\, r^4 \cos\psi \sin\psi}{r^3 \left\{ 3 \cos^2\psi - 1 + \gamma(1 + \mu) \right\} - \mu a^3}$$

ou, par approximation

$$\frac{\partial r}{\partial \psi} = \frac{3\, r^4 \sin 2\psi}{2 \mu (\gamma r^3 - a^3)}$$

"Il y a donc un maximum de vitesse près de $\psi = \pm 45°$, et on peut dire que les parties de la surface qui possèdent le maximum de vitesse cherché suivent la planète perturbante en longitude de 45° et de 225°.

"Avant de terminer, une seule remarque:—La première formule que je viens d'employer ne donne que des résultats approximatifs, mais, afin de m'assurer du dégré d'approximation qu'elle donne, je l'ai appliquée à un cas où son imperfection devrait se faire sentir davantage, savoir, au calcul des marées terrestres.

"En adoptant pour la Lune:—

$$\mu = 81 \qquad \gamma = (28)^2 \qquad \frac{a}{R'} = 60,$$

je trouve

$$\tau = \frac{R'}{11660000} = 0{\cdot}55 \text{ mètres};$$

en adoptant pour le Soleil:—

$$\mu = \frac{1}{356000} \quad \gamma = (365)^2 \qquad \frac{a}{R'} = 24000$$

il vient

$$\tau = \frac{R'}{26400000} = 0{\cdot}24 \text{ mètres};$$

valeurs, qui sont à-peu-près celles que l'observation a données dans l'Océan Pacifique, tandis que leur rapport:—

$$\frac{264}{116} = 2{\cdot}3$$

s'accorde très bien avec les observations de Brest dont la discussion a donné 2·35.

"*Utrecht, le* 26 *Janvier*, 1867."

Note on the Annual Report, by Mr. De Morgan.—Among Dr. Whewell's writings should have been noted the second or mathematical part of "Electricity," in the *Encyclopædia Metropolitana* (about 1826). It contains, somewhat simplified, the investigations of Poisson, and is the writing in which "Laplace's Coefficients" first got that name.

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MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

Vol. XXVII.	*April* 12, 1867.	No. 6.

Rev. Charles Pritchard, President, in the Chair.

Sir Andrew Scott Waugh, 7 Petersham Terrace ;
Balfour Stewart, Esq., Observatory, Kew ;
William Ladd, Esq., Beak Street, Regent Street ;
S. M. Yeates, Esq., 2 Grafton Street, Dublin ; and
F. H. Varley, Esq., 337 Kentish Town Road,
were balloted for and duly elected Fellows of the Society.

Notice explanatory of a series of MS. Charts, containing the Estimated Magnitudes of Stars visible to the Naked Eye in both Hemispheres, presented by him to the Royal Astronomical Society. By Sir J. F. W. Herschel, Bart.

The examination of a Manuscript Chart containing my views of the comparative magnitude of the stars visible to the naked eye in *Corona* and its neighbourhood on the 9th of June, 1842, having led me to call the attention of the Astronomical Society to the existence of a star distinctly visible at that date in a situation very suspiciously near to the place of the extraordinary star which has recently blazed forth in that constellation,* I have been induced to think that it may not be un-

* See *Monthly Notices of the Royal Astronomical Society*, vol. xxvi. p. 299.

acceptable to possess, for occasional reference, in case of any such occurrence in future, a whole series of similar records, made both at the Cape of Good Hope and in England, in pursuance and part fulfilment of a general plan for observing and recording all the stars visible to the naked eye, and their estimated magnitudes at the dates of their respective observation. I should have gone further in the prosecution of this task, and perhaps, (as regards the northern hemisphere) carried it out to its completion, had not the indefatigable labours of Professor Argelander in the same direction been given to the world while my own work was yet in progress, and induced me to relinquish a task, certainly of great labour, and which henceforward could only be considered as of secondary interest. I think it a pity, however, that the record of a large amount of work which *was* bestowed on the subject by myself should not in some way or other be preserved; were it only for its possible utility to any future observer who, having detected a new variable star, may desire to know whether or not it was visible at the epoch when the particular spot occupied by it in the heavens fell under my observation. And I can think of no better way to secure this object than by consigning the charts to the Archives of this Society (not, of course, with any view to their publication, which is quite out of the question, but) with a view to their preservation, and occasional consultation, when desired. I beg leave, therefore, respectfully to place them before the Society, and request their acceptance of them in their present state, rough and imperfect as it is. In that state I consider them preferable to any copies which I could make, which, though neater and apparently more finished, could hardly be executed without introducing numerous errors.

The basis of the construction of these Charts is the *Atlas Cœlestis* of Bode for the year 1801; the stars in each having been pricked off from those in the *Atlas*, with leading marks for laying down the meridians of R.A. and the declination circles, which were (or remain to be) subsequently drawn, from those indications. The papers being so prepared, and the very large and conspicuous stars (down to the third magnitude at least) indicated in pencil with their letters affixed, (as preliminary guides to the eye) were compared with the heavens; and (as a first result of such comparison) broken up into triangles or compact quadrilaterals of convenient and moderate area; which were then outlined in pencil for examination of their contents, *seriatim*, as opportunity and weather should occur. Each angle of the several figures was occupied by a star sufficiently distinguished to admit of no doubt as to its identity. In this way the whole surface of the heavens was resolved into 738 compartments (not, perhaps, as it turned out, always the best chosen) which, for brevity, although not always such, I shall call triangles. In each of them when sub-

jected to individual scrutiny, the stars were laid in (in pencil at the time—subsequently perpetuated in ink) with their estimated magnitudes represented by numeral figures, unaccented, or once, or twice accented to denote fractional magnitudes (as for instance 5, 5′, 5″ to denote 5m, 5..6m, 6..5m) so as to break each whole magnitude into three "grades." In estimating these grades, neighbouring stars were compared, so as to preserve, as well as might be, a consistency of scale.

This, at least, was the system adopted and adhered to after working in some few of the earlier triangles. In those dated in January, February, and March 1837, the stars visible in each triangle were merely marked in the order in which they were seen (and therefore *most probably* in the order of their magnitudes), as denoted by small figures ①, ②, &c., and inclosed in circles and attached to each. Lettered stars, however, were usually not so numbered. But this system of notation was soon found to be inadequate, and in the charts of the later months of 1837, and all subsequent, the magnitudes were attached. In all cases, however, when all the stars in any triangle which could be discerned on the night of observation were marked (whether Bode's or not) the triangle was considered as "worked," and marked either with a single or double cross (× ⨳) or with the sign △. The stars of the 5th, 6th, or 7th magnitudes surrounded with a circle are from Bode; those not so surrounded, or inclosed in a small triangle, have been laid in by the eye, from configurations with the neighbouring known stars. In some of the Cape Charts the relative magnitudes of the angular stars were attempted to be indicated by the greater or lesser sizes of their pencilled disks, which are carefully preserved in the subsequent ink-marks.

The stars pricked down from Bode in the Skeleton Charts (except in crowded districts) comprised all or nearly all marked by him as 6m. and upwards—rarely, if ever, any marked as 7m. It is unnecessary to say that the estimated magnitudes, attached from actual observation, are not unfrequently very different from Bode's.

In "working" any triangles, the *numerical* magnitudes of the angular stars, when very conspicuous, were not very scrupulously attended to, these having been made, or intended to have been made, the subject of special photometric determination. The results of this, so far as it has extended, are already before the public in my Cape Observations (for Southern stars) and for Northern ones in the Appendix to my *Outlines of Astronomy*. In the interior area, the stars pricked off from Bode (but no way otherwise distinguished except by the letters attached in the Atlas, which were annexed in pencil to the pin-mark) were first looked for. If found they were *pencilled* in, and the estimated magnitudes annexed; if not, the fact was usually indicated by crossing out the pin-mark and attaching the words "*not seen*," or their abbreviation

"*ns.*" Occasionally a small opera-glass was used in such cases, which explains the occurrence of the remark "*not seen,*" (or "*ns*") "*in op. gl.*" The dates of working the Charts, and for the most part of the individual triangles, stand recorded on the sheets.

The presence of any portion of the Milky Way in a triangle was, for the most part, carefully noted, and the relative intensity of its several regions imitated as well as the feeble light used for marking the stars, and the more or less dampness of the paper, would allow. These indications have been allowed to remain in pencil, as they could not be inked without altering the relative intensity of the shading. The delineation of the Milky Way, however, was made a matter of separate and independent study.

Each triangle is numbered, and the numbers are entered correspondingly in two INDEX CHARTS, pricked off from those of Bode, marked as *Hemisphærium Arietis* and *Hemisphærium Virginis*, in which also I have pencilled in, from the working charts, the course of the Milky Way; which may (though rudely done) offer some interest, as the only representation (so far as I am aware) of the whole course of that wonderful zone through both hemispheres, which has yet been given from individual personal observation. The Magellanic Clouds are also laid down in their true places,—the larger in triangles 383, 384; the lesser in 316.

It will be noticed that two sets of numbers occur, the one series in black ink, the other in red. This arose from some of the quadrilateral or polygonal figures used in the working of the charts having (as an after-thought) been broken up into triangles, for convenience of reference: a black-ink polygon thus forming two or more red-ink triangles. The red are those to be adopted and adhered to, should any occasion arise for future reference.

To facilitate such reference, an index is annexed, numerically arranged, in order of the red-ink numbers, by the help of which (the triangle referred to being first found on the Index Charts and its number ascertained) the particular chart or charts on which it has been worked is identified as R A S. 1; R A S. 2; &c. up to R A S. 113. The first 101 of these charts are on paper of uniform size (4to demy). The others, (unfortunately) are of irregular sizes; but their numberings are continued on, as if uniform, from R A S. 102 up to 113.

Collingwood, Jan. 26, 1867.

Catalogue of Micrometrical Measurements of Double Stars. By the Rev. W. R. Dawes.

The *Introduction* to the Catalogue is as follows :—

The series of Micrometrical Measurements of Double Stars, which I have now the honour of presenting to the Royal Astronomical Society, contains all the measures obtained between the close of my second series (published in the *Memoirs R.A.S.* vol. xix) and the present time. The former and principal part of the series contains the observations made to the end of the year 1854; to which is added an Appendix, containing such as have been subsequently effected. The Catalogue itself is preceded by a description of the different micrometers employed.

In the computation of all the Mean Results, the weights attached to the individual measures when made have been introduced,—the sum of the weights of each set representing its aggregate value on the plan adopted in my two previous series of assigning 10 to a measure judged to be as perfect as possible. The sum of the weights attached to a single night's measures of any object is always below 100; and in computing the mean of several nights' measures, the labour of the necessary multiplications and divisions has been greatly alleviated by the use of "*Crelle's Rechentafeln;*"—a work which is in fact an extension of the multiplication table to 999 × 999.

To the first and principal portion of the Catalogue, and also to the Appendix, are attached *Notes* on each star which I have measured; in which are collected for comparison the results obtained by other observers. In most cases these comprise all with which I was acquainted; while in others, principally those of least interest, a liberal selection has been deemed sufficient. In this part of the work I have profited greatly by the kindness of the late Professor Struve and of Professor Mädler of Dorpat in forwarding to me many of the volumes of the Dorpat Observations; and also of Professor Secchi in sending me the volumes of Memoirs of the Observatory of the *Collegio Romano*, containing his observations of double stars. Mr. Otto Struve also, to whom I had communicated my measures of several of the stars discovered by him at Pulkowa, sent me in return the results of his own observations of them for comparison with mine. These are introduced in the comparative series, and are in fact in several instances the only observations with which mine could be compared. Some very valuable results which have been communicated to the *Astron. Nachr.* by Professor *Kaiser* of *Leiden*, and by the Baron *Dembowski*, have also been introduced

The Repeating or Parallel-Wire Micrometer, employed at Mr. Bishop's Observatory, South Villa, Regent's Park, London.

The arrangement of the wires in this micrometer, constructed by Mr. Dollond, was assimilated to that of the micrometer which I had used at Ormskirk;—two parallel metallic wires being inserted at right angles to the moveable webs, and their interior edges being about 12″ apart. Between these the double stars were placed for the measurement of the angle of position, the micrometer being turned in position till the direction of the wires was judged to be parallel to an imaginary line joining the centres of the stars. The advantage of using the thicker wires instead of the fine spider lines for the measurement of position is very considerable in reference to the firmness of the judgment formed by the eye; and from the very feeble illumination requisite for their visibility, stars can be observed in position fully one magnitude below the limit which would be imposed by the use of sufficient illumination of the field to render the spider's webs distinctly visible.

Besides these fixed wires, two others were inserted parallel to the fine webs, and moving with them. These, however, though useful for cometary observations, were never employed for measurements of the distance of double stars.

The position circle of this micrometer is read off by its two opposite verniers to a single minute. The value of one revolution of the screw was found to be 15″·955. The thickness of each of the fixed and moveable wires was 3″·54 in arc; and of the spider's lines 0″·73.

A concave achromatic lens made by Dollond (as suggested by Professor Barlow, and therefore most appropriately called, "The Barlow-lens,") was occasionally inserted between the object-glass and its focus in the manner mentioned in the *Introduction* to the first series of my observations of double stars made at Ormskirk (*Memoirs R.A.S.* vol. viii); and more particularly explained in the Introduction to the second series. (*Memoirs R.A.S.* vol. xix.) It nearly doubled the magnifying power of the object-glass; and the value of one revolution of the micrometer screw was thereby reduced to 8″·243.

In measuring distances, one of the webs was always fixed by a bolt which effectually prevents any accidental change in its place; and the measures were made by means of the moveable web on each side of the fixed one, the zero correction being thus eliminated. This plan I have always employed in observing with the parallel-wire micrometer.

A very important aid to the convenient and accurate use of this micrometer is the piece of mechanism termed a *slipping-*

piece. This, being applied to the tail-piece of the telescope, receives the micrometer into a stout plate of brass which is moveable in right ascension and declination by fine screws. A double star can thus be brought precisely into the middle between the position wires; and either of the webs can be placed upon either of its component stars with ease and certainty.

The magnifying powers produced by the double eye-pieces belonging to this micrometer were about 63, 105, 185, 320, 420, and 600. Two more, magnifying 190 and 300, were added to the original series for the sake of avoiding the inconvenience of changing the adapter during observation. With the addition of the BARLOW-lens, the powers were about 122, 203, 360, 368, 580, 620, 810, and 1160. Of these, 360 and 620 were alone employed.

A double convex crossed lens, giving a power of 520, was used on a few occasions.

Description of the Prismatic Crystal Micrometer employed at the South Villa Observatory.

As there seems to be some personal peculiarity attaching to most observers with the repeating or parallel-wire micrometer, it appeared to be very desirable to compare the results, in distance especially, obtained by means of that instrument with those which might be procured of the same objects with a double-image micrometer. Having in the year 1842 conferred with Mr. Bishop on this subject, I was requested by him to order from Mr. Dollond such an instrument as I considered most suitable to the purpose. I had no hesitation in giving the preference to some application of the double-refracting crystal, as it is of prime importance that in the measurement of the position of double stars the images should be as good as possible. The scale of the *spherical* crystal micrometer being far from uniform, and also of very small extent, though as made by Mr. Dollond it gives beautiful images, it was resolved to adopt a modification of Rochon's plan of producing a double image by causing a double prism of rock crystal to slide along the inside of the tube. Mr. Dollond had previously constructed such with the substitution of a sphere of the same substance for the usual magnifier or eye-lens; which, by its rotation on an axis at right angles to the plane of double refraction, was used to complete an approximate measure made by means of the sliding prisms. The want of uniformity of the scale of the sphere introducing some uncertainty in the result, I preferred the use of single crossed convex lenses as magnifiers; and had three such applied, whose powers on the South Villa refractor were, 185, 350, and 520. By adjusting the length of the adapting tube of each

lens to its focal length, the lens is brought as near as can be allowed to a fixed plate, which carries two fine spider-lines at right angles to each other, and crossing in the centre of the field. These lines being as close as possible to the surface of the eye-lens when pushed home are quite invisible, and do not sensibly disturb the image. One of them is placed precisely in the direction of the separation of the images, so as to bisect both the images of a single star when widely separated; the eye-lens being drawn out till the line is in focus. Then, by turning the position-circle till a star runs along this line, the zero of position is given by the reading of the index, which will be 90° when there is no index error. The angle of position (which is read off by the two opposite verniers to one minute) was obtained by bringing the four components of the two images into a straight line alternately on both sides of the point of single vision; and the mean of the readings was adopted. With the first set of prisms the secondary image did not pass the fixed image quite centrally; but the difference of the observed angle on each side was not such as to render necessary a correction of the double distance measured by placing the four stars at equal distances. By the mean result of a great number of careful observations on artificial stars, the nearest approach of the centres (a) was found to be $0''\cdot1559$. Where, however, in consequence of the distance being too great to allow of the measures being made on both sides of the point of single vision, or from any other cause, the observations were confined to one side, a correction to the angle was calculated by the formula, *tan. of angular correction*$=0''\cdot1559\times 2d$; —$2d$ being the double distance measured by the micrometer. In all such cases the fact is mentioned in the notes that a zero of distance has been employed, and a calculated correction applied to the measured angle. The zero-point has in these instances been deduced from measures on both sides of zero, taken with the same eye-lens either on the same night, or very near the time of observation. From the construction of the instrument, the zero reading is very different with each of the eye-lenses; but the fluctuations of that reading were very small, far less in fact than the probable errors of observation.

From some subsequent observations on artificial stars, it appeared as if the nearest approach of the centres were not precisely the same with the different eye-pieces; but as the variations were very small, and the amount not very certain, the value of a above given was adhered to, being extremely near the mean of all the results with power 350, which was the one most frequently employed. The value of one division of the scale with these prisms was $0''\cdot5742$, determined by the interval of time between the transits of the two images of a juxta-polar single star over the web placed perpendicular to the direction of motion.

A new set of prisms inserted by Mr. Dollond was used after 1843, Aug. 16, with which the passing of the images was so nearly central that no correction to the angle was required. The value of one division of the scale with the new prisms was determined to be $0''\cdot 28986$.

It is essential to accuracy that the object should be pretty near the middle of the field of view. When the driving clock goes well, there is no difficulty in keeping it there; but as the field was usually dark when this micrometer was employed, a little illumination was occasionally admitted to render the margin of the field visible; or the eye-lens was withdrawn till the cross webs became visible on the enlarged image of the object, which generally had sufficient light to render illumination of the field unnecessary for this purpose.

On the whole, I formed the opinion that the angles of position measured with this micrometer (by placing the four stars in a line) are not quite worthy of the same confidence as those procured by placing the image between the thick parallel wires of the repeating micrometer; notwithstanding that the double image is as perfect, or very nearly so, as the single image with an ordinary eye-piece. The distances, on the contrary, I believe to be as accurately measured as the observer's eye was capable of under the atmospheric circumstances. And very tolerable measures of distance may be obtained by the estimation of equal intervals between the components, even when the stars are so violently and rapidly agitated that the webs could not be kept on their disks for an instant, and the observer's eye would soon be distressed and wearied by continued and ineffectual attempts. Moreover, a less perfect action of the driving clock is needed with a double-image micrometer than with the parallel-wire micrometer.

This micrometer is referred to by the abbreviation, *Pr. Cr. M.*

Description of Merz's Parallel-wire Micrometer.

The parallel-wire micrometer which accompanied the equatoreal made for me by Merz and Son, of Munich, in the year 1846, differed considerably from those usually constructed in this country. Only one of the micrometer screws has a graduated head, the other carries the thread on either side of which the measures of distance are made; but it is not furnished with the means of bolting or otherwise fixing the thread at any given point. The only threads in the field are the two parallel spider's lines, with which the measures both of position and distance are taken. The number of whole revolutions of the screw are conveniently read off on the outside of the micrometer frame;—an arrangement which does not, like the interior comb, require illumination of the field and the application of a low power to render the scale visible, and which might therefore be advantageously copied by in-

strument-makers in this country. This micrometer was furnished with the means of illuminating the threads in a dark field; but I soon found that though useful for *approximate* measurements of objects too faint to bear illumination of the field, they could not be depended on for *accurate* determinations of distance; and no observations thus made are included among the measures in the following catalogue.

The value of one revolution of the screw was found to be 25″·606. This micrometer was furnished with seven double eye-pieces, whose magnifying powers on the 8½-foot object-glass, of 6⅓-in. clear aperture, were 120, 155, 260, 322, 435, 572, and 690. These powers, as well as all others quoted in this catalogue, were determined by careful measurement of the emergent pencils. The real powers are therefore not smaller than the quotations. This is to be taken into consideration in comparing the powers used in my observations with those employed by Professor Struve at Dorpat, in whose great work (*Mensuræ Micrometricæ*) the powers are quoted as stated by the maker, though the actual powers were found by Struve himself to be much less, as appears from the following table given in the Introduction to that work:

Eye-pieces of the Parallel-wire Micrometer of the Dorpat Refractor.

No.	Nominal power.	Actual power.
1	94	86
2	140	133
3	214	198
4	320	254
5	480	420
6	600	532
7	800	682
8	1000	848
9	1500	1150
10	2000	1500

The spider's lines inserted by Merz were beautifully round and uniform in thickness; but they were inconveniently thick for measurement in distance of very close stars, and totally occulted very small ones. Wishing to try the effect of the Barlow concave achromatic lens in diminishing the arc subtended by the threads, I requested of Sir John Herschel the loan of one which had been made by Mr. Dollond for him before his departure for the Cape of Good Hope; and finding that it perfectly answered my purpose, he kindly presented it to me in December 1846. From that time this lens has been frequently used; and the magnifying powers of the four lowest eye-pieces of the micrometer were increased to about 300, 387, 648, and 803; and the value of one revolution of the micro-

meter screw was 10″·268. The defining power of the object-glass was not sensibly impaired by the intervention of this lens.

This micrometer continued in use till 1848, Feb. 25, when I exchanged it with Mr. Lassell for a parallel-wire micrometer made for him in 1839 by Mr. Dollond under my direction, in which the system of thick wires and webs was similar to that which had been inserted into Mr. Bishop's micrometer, as stated above.

The eight eye-pieces of Dollond's micrometer produced the following powers on the 8½-foot refractor, 87, 136, 200, 268, 353, 467, 591, and 780. With the BARLOW-lens interposed, the powers of the six lowest became 163, 252, 375, 500, 658, and 870; the tube of the BARLOW-lens having been somewhat shortened, and its effect therefore rather diminished. One revolution of the screw was equal to 19″·9935 on the Munich refractor, which on the application of the lens was reduced to 10″·680.

It may be well to mention here that I have found it very convenient to have the tube of the BARLOW-lens divided into several pieces, any of which can be used, and thus any degree of relative fineness of the webs secured. The value of the micrometer screw will of course require to be ascertained for each length of the tube.

Description of the Spherical Crystal Micrometer.

Two of these instruments have been occasionally employed since the erection of my Munich equatoreal at Cranbrook in the autumn of 1846. Both of them were made by Dollond, who first contrived this form of double-image micrometer. One had belonged to Mr. F. Baily; and after his death it was purchased at the sale of his library and instruments by Mr. R. Hodgson, who obliged me with the use of it to the close of this series of double-star measures. It has a small position circle, but is not furnished with any means of determining the zero of position. To obviate this defect, I fixed temporarily a fine wire upon a diaphragm in the focus of the sphere. The zero of position was then determined by letting a star travel along this wire; and the angles were measured by placing the wire alternately on each side of the *single image* of a double star, and thus judging of the parallelism of the wire to the imaginary line joining the centres of the two stars. I believe this method to be considerably more accurate than placing the stars of the two images in a line; and even than attempting to bisect both the stars of one image by a fine web; yet as the result is inferior in precision to that obtained by placing the double star between two parallel wires, I have allowed to such observations only half the weight which would have been assigned to them if taken by the latter method.

The measurement of distance with this micrometer is effected

by the rotation of the sphere upon an axis perpendicular to the plane of double refraction. The same axis carries an index which shows on a circular arc the number of degrees through which the sphere has rotated on either side of the zero point of the scale in the middle of the arc. The greatest separation of the images occurs at 45° from the zero point.

Though the greatest distance measurable with such a micrometer is only about 13″ or 14″ when the magnifying power is 100; and, varying inversely as the power, becomes very small when the micrometer is attached to a telescope of long focus; yet from the excellent images it gives when worked as perfectly as those I have employed, (all made by Dollond,) it must long ago have been considered a very useful instrument for the measurement of very small angles if the degrees of the arc, over which the index passes as the sphere is rotated, were of equal value; or, in other words, if the value of the scale were uniform throughout the arc. But this is very far from being the case, as immediately appears from experiments; and this reason is given by Dr. Pearson in his "*Practical Astronomy*" for laying it aside as useless.

Being unacquainted with any experiments from which the law of variation could be deduced, I determined to institute such a series as would give with great accuracy the values at several points of the scale. For this purpose I applied a parallel-wire micrometer to a telescope on which the value of one revolution of its screw had been well ascertained; and employed the telescope so furnished by way of collimator to another telescope to which was applied the spherical crystal micrometer; the focal length of each object-glass having been very accurately determined. The moveable webs of the parallel-wire micrometer being thus rendered perfectly distinct to an observer with the spherical micrometer, they were set to a succession of equal intervals, which were most carefully measured by daylight with the spherical micrometer on each side of its zero point. These measures expressed in parts of the index arc (a circular scale) being laid down as abscissæ, and seconds and fractions of a second as ordinates, on a sheet of small squares, a curve was drawn through the points indicated, and the readings tabulated to each degree of the scale. Any considerable and irregular variations in the differences of consecutive values, arising from the combined effect of errors of observation, of drawing the curve, of reading it off, and of imperfections in the form of the squares themselves, were subsequently smoothed down. This plan having been carried into effect with both the spherical micrometers, it became obvious that the law of variation was the same in both; and after a little consideration I found that the value of the angles indicated by the index varied very nearly, if not precisely, *as the sine of twice the angle through which the sphere rotated*, commencing from the zero point. On a focal length of 102·5 inches, the largest arc

measurable with one of these micrometers (designated as No. 1) is $2''\cdot85$,—the index then pointing to 45° on the circular scale: and with the other micrometer (No. 2) the largest arc on the same focal length is $7''\cdot70$. From these values tables were calculated of the value corresponding to each division of the scale. In only 9 out of the 45 values in No. 1 did the difference between the value deduced from the observations and the value given by calculation amount to $0''\cdot01$; and of these 9, four are + and five are —. The results of the calculation therefore appear to represent the true values quite as correctly as they could be deduced from any series of observations.

Putting r = the value of the separation of the images on any given focal length when the sphere is turned through 45° from the zero point,

the value ϱ of any other angle θ indicated by the index will be given by the formula,

$$\varrho = r \,.\, \sin 2\theta$$

The value of r will of course vary inversely as the focal length of the telescope to which the micrometer is applied.

This micrometer is referred to by the abbreviation, *Sph. Cr. M.*

Description of Amici's Double-image Micrometer.

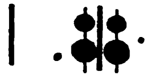
This micrometer was constructed by the late Professor *Amici* of *Modena* for Sir John Herschel; but it was furnished with only one eye-piece which was of an inconveniently high power,—magnifying nearly 1000 times on the 20-foot reflector, for which I presume the Professor designed it, as the position-circle is graduated suitably for a front-view reflector. It was, I believe, but little if at all used by Sir John in his observations at the Cape. As I was desirous of trying such a micrometer on my refractor, Sir John lent it me for that purpose, and I found it very efficient on many objects. In reply to a favourable report of its performance, Sir John most kindly made me a present of it as a new year's gift on the first of January, 1855. I soon after had some important additions made to it by Dollond, by which its usefulness was greatly increased. The principal of these was a sliding tube, which could be accurately fixed at four different lengths, at each of which the divisions on the scale have a different value;—thus extending the use of the micrometer for wider stars, and giving a finer scale for very close stars, than was possible with the original tube of a fixed and unalterable length. Three new double eye-pieces were also applied, which on 100 inches of focal length produce powers of about 212, 360, and 508;—the original eye-piece giving a power of 380. On a diaphragm I

had two very stout and beautifully round spider's lines fixed parallel to each other, and at about 10″ apart, for the measurement of angles of position.

When the whole aperture of the object-glass is used, the divided glass of the micrometer makes a spectrum of each star; and in this form it is of course almost impossible that good measures of position should be obtained. When however the stars are not extremely close, (the central distance not less than 1¼″ when an 8-inch object-glass is in use,) the disks may be made beautifully round by employing a double circular or figure-of-eight aperture, or an elliptic aperture:—as I have shown in my paper on the use of this micrometer inserted in the *Monthly Notices*, vol. xviii, No. 3.

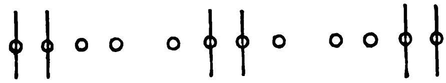
Another plan which I contrived soon after this instrument came into my possession, and which I would take this opportunity of specially recommending to the attention of astrometers, is this. Instead of the tube containing the eye-pieces, I had my parallel-wire micrometer adapted to the Amici micrometer. The thick parallel wires in the former are easily brought to coincide with the direction of separation of the images in the latter; and thus the single image when nicely central and well defined may be measured in position by those thick wires; or, when the double-circular or elliptic aperture is employed, and the stars in each of the images are therefore round and neat, *one* of those images may be measured in position by placing it between the thick parallel wires. But there is this peculiar advantage in this kind of double-image micrometer for the measurement of double stars, that by moving the object but a small distance from the middle of the field all the rays may be made to pass through one of the halves of the divided glass; and thus the advantage of the whole aperture will be secured both in its *illuminating* power on very *faint* objects, and in its *separating* power on very *close* ones.

Another mode of measuring the angle of position which I have occasionally practised when the double-circular or the elliptic aperture has been in use, is, I think, worthy of adoption in some cases, especially where it may be desirable to test and compare the results of different methods on the same object at the same time. In this method, the thick wires are placed *at right angles* to the direction of separation; and the two images being separated by a few seconds only, one of the images is placed on each side of one of the thick wires. The images may be separated to various distances, and the effects compared together.



For the measurement of distances also, there is considerable advantage to be derived from this combination of the double-image and parallel-wire micrometers. The thick position-wires being placed *parallel* to the direction of separation, the fine webs should be placed as exactly as possible on the centres of the components of one of the images; and then, by delicately

moving the objects in the field, the three intervals, formed by placing the four stars in the two images at equal distances, are brought to the webs in succession : and thus their equality is tested to the greatest exactness of which the eye is capable. This may be illustrated by a diagram. Such a mode of



using the webs, it will be understood, is intended merely to assist the judgment of the eye in making the interval between the two images exactly equal to the distance between the components. And this method may be employed when the whole aperture of the object-glass is in use ; for the prismatic images of the stars being elongated in the direction of the webs, the *distance* may be correctly measured, though the *position* cannot.

Another and by no means an inconsiderable advantage of thus combining the two micrometers is this ;—that the measures of distance are performed with both micrometers at the same time, and therefore under precisely the same condition of the atmosphere, of the instruments, and of the observer himself :—the last being sometimes by no means the least in importance.

It is obvious that the Barlow-lens may be used with this micrometer, or combination of micrometers ; so as to bring the value of the scale to what may be deemed most convenient.

Description of the Four-glass Double-image Micrometer.

In the early part of 1860 I received from Mr. Simms a 4-glass double-image micrometer, with all the latest improvements contrived or approved of by the Astronomer Royal. It was furnished with four first-lenses of different focal lengths, by the change of which the magnifying power is varied. The powers as first arranged were such as on a focal length of 100 inches would be about 150, 258, 430, and 540. Finding that the highest was more than would be needed for such a micrometer, except on very rare occasions, I had it changed for a power of about 80 on 100 inches of focal length, which for wide stars is often convenient.

In the focus of the positive eye-piece formed by the two glasses nearest the eye, I had two parallel thick webs inserted for the measurement of position-angles ; and they can be easily placed either parallel or perpendicular to the direction of separation of the images. A prism is adapted to the eye-piece to enable the observer to place the double star in any apparent position he may desire.

In a paper which I had the honour of presenting to the Society in Jan. 1858, "On the Measurement of Position-angles with a Divided-glass Double-image Micrometer," I noticed

the possibility of producing round images by introducing a diaphragm before the divided glass of the micrometer;—such diaphragm having "two circular apertures touching each other in a point coinciding with the line of collimation of the telescope, and the diameter of each aperture exactly equal to the semi-diameter of the cone of rays at the distance of the diaphragm from the focal point of the object-glass." And with reference to its practical application I remarked that, though it would have the advantage of turning with the position circle, and thus obviating the necessity of altering the position of the double-circular aperture (when such a one was placed before the object-glass) for each double star observed; yet that there would be great difficulty in exactly proportioning the size of the apertures in the diaphragms to the powers employed; and also in illuminating the field sufficiently to enable the position-wires to be pleasantly seen. In making the micrometer for me, Mr. Simms acted upon this suggestion, and introduced one such diaphragm for each power of the micrometer. But though the utmost care has evidently been taken to proportion the excessively minute apertures correctly, I found that the apertures for the highest power (593 on my 8¼-inch object-glass) were not only too large for that power, but even for the next lower, (472): proving that the difficulties I anticipated were practically almost insurmountable.

It may be well however to mention here, as it was inadvertently omitted in the description of the Amician micrometer, that in that form I have frequently used a diaphragm placed nearly in contact with the divided glass, and pierced with two minute holes as above described. But though this form of micrometer is more favourable to the application of such a diaphragm than is the 4-glass micrometer, inasmuch as one pair of holes is sufficient for all the different powers, yet I must confess to my decided preference for the double-circular or elliptic aperture placed before the object-glass; especially when the parallel wires are used for measuring the position, and illumination of the field is therefore necessary.

To render more easy and certain the turning of such an aperture to the proper position, I had the brass dew-cap of my telescope divided to every 5° by bold strokes on the outside of the distant end; the zero, or 0°, being coincident with the middle of the declination axis, and consequently 90° from the zero point of the position circle of the micrometer when properly adjusted. The observer then has nothing to do but to take an approximate measure of the position of the double star he is about to observe, (if the approximate angle is not previously known,) and to set the line which passes through the centres of the two circular apertures, or the major axis of the elliptic aperture, to the same angle engraved upon the dew-cap.

By a small addition to the instrument as usually made, the 4-glass double-image micrometer may be converted into an

Amician. This I contrived by having a tube made to apply in the place of the usual eye-tube, and furnished with an adapting screw, into which all the eye-pieces of the wire micrometer might be fitted. It must, however, be acknowledged that the 4-glass micrometer converted into an Amician does not make so good an instrument as the originally constructed Amician,—the divided glass being too deep a concave.

One great advantage of the Amician form is, that any desired change of magnifying power can be made during the time of obscuration by merely changing the eye-piece, and consequently without any risk of disturbing the zero adjustment of the position-wires; which can scarcely be done where, as in the 4-glass micrometer, the optical portion has to be removed to change the first glass. Moreover, in the Amician the change of power does not alter the value of the scale, as it does in the other.

Another very useful purpose to which the 4-glass micrometer may be applied is, as a *double-image dynamometer.* But on this subject I hope to submit to the Society a few remarks in another communication.

I may here advert to one or two points which the experience of more than five and thirty years has convinced me are of some importance in the measurement of double stars both in position and distance. And first in *position.*

1. The thick position-wires having been turned, as nearly as can be estimated, into the same direction as the imaginary line joining the *unequal* components of a double star placed midway between them, the stars should be brought nearly to touch one of the wires alternately on each side of it; by which a tendency to place one of the double wires nearly in the direction of a tangent to the disks of moderately unequal stars, may not unfrequently be detected. When such stars are *between* the wires, the eye may unconsciously be directed to the edge of one wire rather than of the other; but the placing of the star alternately on either side of the same wire will immediately remove this tendency.

2. The wires having been brought up approximately to the right direction, attempts will usually be made to improve the measure by repeated small movements of the wires in the same direction,—the eye being kept intently fixed upon the stars. Very soon after I commenced my double-star observations, I became conscious of a tendency in the eye to accommodate its judgment to the position of the wires before they had been quite brought up to the right point. And thus, if the wires were alternately brought up from opposite sides of the true direction, the resulting measures would be alternately too large and too small. I was much interested some time ago in some remarks on this subject by that excellent and indefatigable double-star observer, the Baron *Dembowski,* who had detected

the same tendency in himself. To remove the error arising from it he adopted the plan of bringing up the wires alternately from each side of the true direction, and taking the same number of measures each way. This is exactly the same plan as I adopted for some years; and I still continue always to derange the measures, as soon as read off, alternately in opposite directions. But I have now for many years practised a mode of observing which yields a far more uniform series of results. When the eye is not quite satisfied with the position of the wires, and a succession of small alterations is required in the same direction, I always remove my eye from the telescope for a few moments after each alteration; and thus endeavour to get rid of the previous impression, and to bring up my eye fresh to its work. I find that a more independent and correct judgment is thus formed; and the individual measures are usually much more accordant, and always free from any systematic differences.

3. In the measurement of the *distance*, of rather close double-stars especially, I have found it very useful to previously place on each of the stars, as centrally as possible, a single web of the parallel-wire micrometer; and carefully to note the change which is thus made in the form of its disk. The effect on a star of moderate size is to *swell out the disk on each side of the web;* so that if the part of it covered by the web were supplied, the figure instead of being round would be nearly elliptical. The consequence of this is, that in a double star just neatly separated with the aperture and power in use, the swelling out of the disks obliterates the interval between them, and renders it very difficult to judge of the bisection of the disks. If however the form of each disk when bisected by the web has been accurately noted, a trustworthy measure of the distance may be obtained by placing the webs so as to produce on each the same effect as was previously observed. But if this effect is not known or is disregarded, the measure will almost inevitably be considerably *too large;* the webs being placed too near the outer edge of each disk.

I cannot but think that some such cause as this must have produced the enormous excess of the measured distance in many objects in the early observations of some excellent observers, as may be seen in the series of results brought together for comparison in the *Notes* appended to the following Catalogue. For my own part, I am conscious that until I detected this source of error, it was one of the causes which produced the same effect on my earlier measures of distance. But the principal cause of their excess was, that I then imagined the only measures I was acquainted with, contained in the *Phil. Trans.* for 1824 and 1826, were standard results to which my own ought to approximate; and consequently I tried to accustom my eye to the largest measures it could endure. This delusion was in part dissipated by finding that, in the case of such a star as

ζ *Aquarii*, (whose position-angle was not far from 0°,) when its distance was deduced from excellent observations of the difference of declination, obtained by letting the stars pass through the field threaded on the micrometer-webs placed on each side of zero, that distance was actually less by more than 1″ than those contained in the comparative series under date 1822 and 1828. I refer to this fact especially to guard against the conclusion that, because more recent observations show in many cases a large diminution of distance, a real approximation of the components must therefore have actually occurred.

Remarks on the Use of various Telescopic Apertures.

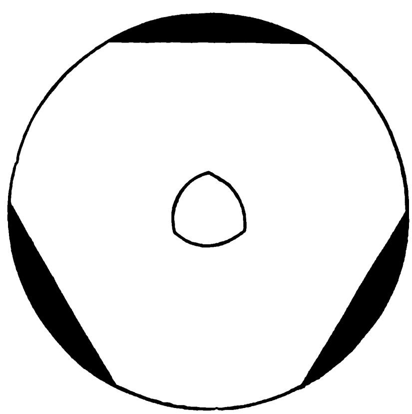
1. Sir John Herschel has recommended the use of a round disk placed centrally before the object-glass, having a diameter from a sixth to a fifth of that of the object-glass. In the *Introduction* to my first series of double-star measurements, (see *Mem. R.A.S.*, vol. viii., p. 63,) I have referred to the effect of this application as increasing the *separating* power of the telescope, but at the same time increasing both the number and the brightness of the rings round the brighter stars. They are also thrown further from the disks; the small companions of rather bright stars are often hidden by them; and the disks of nearly equal stars are apt to be elongated by the rings passing through them. I have therefore seldom used this expedient, though in some instances it is undoubtedly advantageous.

2. I have frequently found great advantage from the use of a *perforated whole aperture*. The perforated card-board used for making the Berlin wool-work is very suitable for bright stars, such as *Castor*, γ *Leonis*, γ *Virginis*, or even ζ *Bootis*. At some distance from the star are arranged highly coloured prismatic spectra of great beauty. The effect of this aperture on *Venus* is exquisitely fine, producing a central image of the planet perfectly colourless, and very sharply defined. The area of the exposed surface of the 8¼-inch object-glass scarcely exceeds that of a 2-inch object-glass. But when the object is not sufficiently bright to bear so great a loss of light, a smaller degree of the same effect may be produced by a disk of card-board, of which a circular portion of the size of the object-glass is pierced with holes of equal size arranged in concentric circles. The one I have principally employed with an 8¼-inch object-glass, has 15 circles containing with a central one 770 holes. They are all 0·2 inch in diameter; so that the exposed surface of the object-glass is about equal to that of an object-glass of 5½ inches. The effect of this is very agreeable. The disks are considerably smaller than with the whole aperture, in consequence of having less than half the brilliancy; the ratio of the area being nearly as 0·45 to 1; while the effect of the whole aperture in reducing the diameter

of the disk is also preserved. The brightness of the rings is also proportionably diminished, and except on very bright stars is scarcely perceivable. Around these there are concentric prismatic rings, but at such a distance as not usually to interfere with companion stars.

3. A different and in some respects a still more useful effect is produced by the employment of *angular* apertures. Sir John Herschel has mentioned the inscribed triangle as destroying the rings round bright stars. The principal inconvenience of such an aperture consists in the six bright rays which proceed from the disk at equal distances. Great care is necessary to prevent a small companion from being obliterated or distorted by these rays. The disk of the star is ***not round*** with this aperture, as it has been supposed to be, but ***hexangular;*** and a ray proceeds from each side of the hexagon. If the focus is a trifle too short, the image becomes triangular in one direction; and if too long, in the opposite direction,—the sides in the latter case occupying the situations of the angles in the former. It is therefore possible to obtain an exquisitely fine focal adjustment by reducing all the rays to an exact equality in brightness. The illuminating power of the object-glass is reduced in the ratio of about 0·4 to 1. A kind of aperture usually more advantageous, especially on stars of only moderate brightness, is an inscribed ***hexagon.*** With this the rays (which are six in number, as in the triangle) are much more feeble compared with the greater illuminating power of the exposed area, the ratio of which to the whole aperture is more than 0·8 to 1; or double the area of the inscribed triangle.

4. It is sometimes very desirable to provide an antidote to the curious but annoying tendency which is occasionally seen in the telescopic disks of stars to become triangular, especially when the wind is in the east or south-east. Such an antidote is effectually produced by cutting off three equi-distant segments from the whole aperture of the object-glass, the base of each of which is the chord of 60°. Then, the chords being placed so as to coincide in position with the angles of the telescopic inverted image, those angles will be reduced by the larger circular aperture between the segments, and a fairly round image will be substituted for the triangular one, the form of which usually approaches that of an obtuse-angled spherical triangle; thus,



The production of this triangular telescopic image is a very curious phenomenon, and its association with the east wind seems unaccountable. When I had the honour of receiving the late Professor Struve at my residence in Kent, I mentioned the subject to him; and he said he had often seen it, but could not at all account for it. In reply to an inquiry as to its probable cause, which I made on one occasion of Professor Wheatstone, he informed me that the subject had been investigated by some eminent German astronomer; but he could not recollect the particulars, and I have never received from him any further information. I have noticed it most distinctly in telescopes remarkable for exquisitely fine definition. Yet that it does not arise from anything in the object-glass itself may be proved by unscrewing it one sixth of a turn; when, if the object-glass is in fault, the angles of the triangular image will take the places previously occupied by the sides. I have also had an opportunity of proving this when the phenomenon has been strongly marked, by exchanging the object-glass for another at the time. On the occasion of Mr. Alvan Clark's visit to me in the summer of 1859, he brought with him two excellent object-glasses, one of 8 inches, the other of 8¼ inches in diameter. On an exceedingly fine evening, the stars being almost perfectly quiet, I was trying one of thése object-glasses, and was surprised to find a very strong triangular tendency in the disk of *Arcturus*,—one of the sides of the triangle being nearly parallel to the horizon, but raised a little on the eastern or following side. Mr. Clark saw it exactly as I did. On changing the object-glass for the other, after the telescope had rested on the star for a few minutes the image was as strongly triangular as before, and precisely in the same direction. The wind was in the south-east, but it was nearly calm. I have supposed that the cause must exist in the temperature of the air in different parts of the tube; but if so, it is difficult to imagine why it should be affected by an east wind. That it is so I have frequently noticed, and on one occasion it was proved with remarkable certainty. On an exceedingly fine night, I had been observing with the 8¼-inch object-glass with great delight till near 3 in the morning, the stars having been for several hours beautifully defined and round. At that time I noticed an occasional tendency to triangularity, lasting for a few seconds at a time. These triangular fits increased in frequency and continuance; and I was greatly surprised at it, inasmuch as the gentle wind had been all night nearly in the south-west; and I noted down the occurrence before I left the observatory as being an extraordinary deviation from the usual circumstances. On coming out of the observatory, however, I found that the wind had changed to the south-east!

5. It may be worthy of remark, that a smaller aperture may sometimes show a very delicate and close companion to a bright star, when a larger aperture fails to show it. A singular

instance in illustration of this occurred to me when I was observing at Mr. Bishop's observatory at South Villa in the Regent's Park. After a totally cloudy day, a sudden and complete clearance showed the stars with remarkable brilliancy; and to ascertain whether the night was as fine as it looked, I turned the 5-foot refractor by Dollond (aperture 3·8 inches), which I had at Ormskirk, on to ζ *Herculis*. With power 400 the image was beautifully sharp and steady; and the small companion was usually in loose contact, and at best moments just separated from the large star. The one bright ring passed outside of the smaller star, and in contact with it, but did not distort it. The central distance was at that time about 1¼″. Now, with a 5-inch aperture, the bright ring being of considerably smaller diameter, and also brighter, would pass through the small star, and elongate it to such a degree as to make it appear like a somewhat brighter portion of the ring. Thus it might happen, and I have no doubt has happened, that the companion of such objects as ζ *Herculis* and δ *Cygni* might be seen with a smaller aperture, though invisible with a somewhat larger. It is difficult otherwise to account for the fact that the companions of both these stars could not be perceived by Sir James South with his exquisitely perfect 5-inch refractor under the finest circumstances, and with various powers up to 787.

6. On such stars as the two just referred to, a considerable increase of visibility may sometimes be obtained by a very slight variation in the adjustment of the object-glass with respect to the axis of the tube. To enable this to be made by the observer whenever required, the adjusting screws should be accessible without removing the object-glass; and not placed as they often are within the tube, which of course renders it necessary to take out the object-glass in order to get at them :—an operation by no means free from danger with the feeble light usually employed in an observatory, and the observer probably without assistance. By such variation of the adjustment, the ring round a bright star may be attenuated to almost any extent on one side without perceptible injury to the form of the disk; and thus a very minute companion may be rendered plainly visible, which with a perfect adjustment of the object-glass would not be seen at all.

7. It is a point of considerable interest to determine the *separating* power of any given telescopic aperture. Having ascertained about five and thirty years ago, by comparisons of the performance of several telescopes of very different apertures, that the diameters of star-disks varied inversely as the diameter of the aperture, I examined with a great variety of apertures a vast number of double stars, whose distances seemed to be well determined, and not liable to rapid change, in order to ascertain the separating power of those apertures, as expressed in inches of aperture and seconds of distance. I

thus determined as a constant, that a 1-inch aperture would just separate a double star composed of two stars of the sixth magnitude, if their central distance was $4''\cdot 56$;—the atmospheric circumstances being moderately favourable. Hence, the separating power of any given aperture, *a*, will be expressed by the fraction $\frac{4''\cdot 56}{a}$. The following table is thus calculated, and may be convenient for reference, containing ordinary apertures and the least central distances of stars separable by them:—

Aperture in inches.	Least separable distance.	Aperture in inches.	Least separable distance.	Aperture in inches.	Least separable distance.
	″		″		″
1·0 ..	4·56	4·0 ..	1·14	8·5 ..	0·536
1·6 ..	2·85	4·5 ..	1·01	9·0 ..	0·507
2·0 ..	2·28	5·0 ..	0·91	9·5 ..	0·480
2·25 ..	2·03	5·5 ..	0·83	10·0 ..	0·456
2·5 ..	1·82	6·0 ..	0·76	12·0 ..	0·380
2·75 ..	1·66	6·5 ..	0·70	15·0 ..	0·304
3·0 ..	1·52	7·0 ..	0·65	20·0 ..	0·228
3·5 ..	1·30	7·5 ..	0·61	25·0 ..	0·182
3·8 ..	1·20	8·0 ..	0·57	30·0 ..	0·152

It might be not unreasonably imagined that the brightness of the stars would make a great difference in the central distance to which any given aperture could reach. But though it may make *some* difference, it is in fact far less than would at first sight appear probable. This arises from the much higher powers which the brighter stars will bear; and as the diameter of the disks does not increase in proportion to the power, the separability of all magnitudes is nearly the same, provided the state of the air is such as to bear well the increase of power.

8. Nor is so great a difference as seems to be generally supposed produced by a moderate degree of uncorrected spherical aberration. I was struck with this fact nearly 40 years ago, when I happened at the same time to be in possession of one of the very best, and also of one of the worst, telescopes I ever had. The good one was made for me by Dollond, and was of the ordinary size called the 2-foot; the focal length being 19½ inches, and the aperture 1·6 inch. It had, as was usual at that time, a triple object-glass, and was in a portable mounting with sliding tubes, and furnished with one of Dr. Kitchiner's Pancratic eye-pieces, magnifying from 45 to 180 times; other eye-pieces of the Huyghenian construction being afterwards added. With powers of 60 and upwards the disks of *α Lyræ*, *Capella*, *Rigel*, &c., were shown with scarcely the slightest trace of a ring; and the small companions of *Polaris* and *Rigel* were readily seen, and not by myself only. The former however was often seen by me with the aperture con-

tracted to 1·4 inch; and on one occasion, under an unusually pure sky, with 1·3 inch: and this is the smallest aperture with which I have ever been able to see it with certainty. As a contrast to this exquisite instrument, I had a 45-inch refractor with aperture 2·75 inches; but so bad was the figure that any aperture exceeding 1¾ inch showed considerable spherical aberration; and with the whole the error was enormous. With the aperture contracted to 1·6 inch, the appearance of *Castor* was almost precisely the same as with the perfect 2-foot: and this first proved to me that the ratio of focal length to aperture does not affect the size of star-disks. But notwithstanding the wretched figure of the larger telescope, any increase of aperture beyond 1·6 inch was found to diminish the disks so decidedly that the perfect little glass had no chance in the comparison. The two double sets, which together constitute ε *Lyræ*, were shown with the 2-foot, ε_1(4)*Lyræ*, just neatly separated; and ε_2(5)*Lyræ* in close contact, power 120. But with the 45-inch, both sets were widely separated with the same power. Pursuing these observations, I came to the conclusion that with the 2¾-inch aperture the disks were of the proper size for that aperture; but that round the brighter stars the false and scattered light was enormously too great; and it is principally in this particular that the effect of a bad figure is seen. Hence it follows that the tests of separating power furnished by close double stars are by no means to be relied on as determining the character of a telescope; and further experience has fully confirmed me in this opinion. The severest test of figure is the similarity of the image of a bright star when the focus is a little too long, and to an equal extent too short. If the *rings* in these out-of-focus images are similarly disposed in both cases, the figure is perfect; but a moderate deviation from this perfect equality does not stamp a telescope as bad, or even unfit for delicate work. And it is a fact, which I have proved by experiment, that the difference between an object-glass which bore this most severe test perfectly well, and one which fell obviously short of it, was not to be discovered by any decided superiority of the one over the other, either in separating power upon close double stars, or even in the perception of faint objects close to bright ones; though this latter is more likely than the former. The question is much more important *how* a telescope shows a difficult object, than whether it can show it at all. It is therefore my confirmed opinion that a list of test objects is of comparatively small importance in the trial of a telescope, especially as so much must depend on the eye and the habit of the observer, and the circumstances under which the scrutiny is performed.

9. In measuring the diameter of a planet with the webs in a parallel-wire micrometer, it has no doubt been frequently noticed by other observers as well as by myself, that when the web is brought to touch the edge of the planet's disk, light is

immediately seen on the outer side of the webs through the effect of diffraction. This gives the impression that the measure is too small. But if the web is withdrawn till this effect disappears, the measure will undoubtedly be too large. To obviate the source of this error, I had two sets of stout webs inserted parallel to the single webs, and at a convenient distance from them: the proximate edges of the webs in each set being about 4″ apart. Like the single webs, these can pass each other so as to allow of measures being taken on both sides of the zero point. In measuring the diameter of a planet, the edges of the disk are placed in the middle of the interval between the webs of each set, where they are seen sharply defined and entirely free from distortion. I believe that results thus obtained are much more worthy of reliance than those derived from the use of single webs, and at least equal to those produced by the double-image micrometer.

10. A curious fact with which I have been familiar for more than thirty years, may perhaps be worthy of notice in this place; namely, that stars at small altitudes require a shorter focus than those at large altitudes, to be seen with perfect distinctness. Of course the difference is slight, yet it is decided and constant. It is independent of the brightness of the object, but yet is, I think, most obvious when the actual difference of magnitude is just so far in favour of the lower star as to render its apparent brilliancy equal to that of the higher. I was first struck with it when observing at Ormskirk, with Dollond's 5-foot refractor, the stars η *Coronæ*, ξ *Scorpii*, and μ_2 *Bootis*, within a short space of time; and I have noticed the same with every telescope of whatever dimensions with which I have since observed.

11. It may be a matter of sufficient interest to deserve notice here, that much fatigue of the eye in long-continued observation will be saved by the exercise of great care never to commence observations of any object with too short a focal adjustment. I have met with instances in which young persons, in reality not at all short-sighted, (as was proved by very distant objects and even the features of the Moon being accurately described,) who, nevertheless, in adjusting the focus of a telescope for themselves, would always set it far too short for my own eye, which requires a deep No. 9 concave of Dollond's scale. This obviously arises from an involuntary shortening of the focus of the eye attending the intense effort to see perfectly well while setting the focus. It is well known that such an effort has this tendency; and I cannot doubt that in many instances the projection of stars on the Moon, when the disappearance occurs at the bright limb, arises from this cause. Be this as it may, it is certain that a very adjustable eye soon becomes fatigued by continued observation with a focus much shorter than is suitable to its natural and usual condition; and the adjustment of the telescope will require to be gradually

lengthened. But when care is taken to avoid any constraint upon the adjusting apparatus of the eye, by the instrumental adjustment being at first rather too long than too short, the eye will quietly accommodate itself, and may work on delicate and difficult objects for many hours together without conscious fatigue; and may continue its efforts from time to time, as from experience I can testify, for half a century with scarcely any perceptible deterioration.

Motion of the Solar System in Space. By E. J. Stone, Esq.

In vol. xxviii of the *Memoirs* of the Society will be found a paper by the Astronomer Royal on the motion of the Solar System in space. The method proposed for the treatment of the subject was new, inasmuch as no *à priori* assumption was made of an approximate position of the apex of the Sun's motion. The method was in this Memoir applied to the discussion of the proper motions of 113 stars. The investigation was afterwards calculated to the discussion of the proper motions of 1167 stars. The calculations for this investigation were made in duplicate at the Royal Observatory. The numbers to which I shall in the present paper refer are extracted from the books of calculation. The direct results of this investigation were presented to the Society in a paper drawn up by Mr. Dunkin, *Memoirs*, vol. xxxii. The resulting position of the apex of solar motion was in agreement with the results of previous investigations; the velocity of solar motion was in fair agreement with the result obtained by Professor Ctto Struve. The sum of the squares of the proper motions in parallax and N.P.D. were, however, scarcely diminished by the application of the corrections arising from the supposed solar motion. The comparison, therefore, of the squares of the corrected proper motions and the uncorrected proper motions gave but little evidence in favour of the hypothesis of the motion of the Solar System in space. It has appeared to me that some information for or against the hypothesis of a solar motion in space might be very simply obtained by considering the agreement or disagreement in sign between the proper motions in parallax and N.P.D. and the computed parallactic effects of the assumed solar motion. In this way of looking at the question we are free from any error in the magnitude of the assumed solar motion. The number of stars whose proper motions are discussed in the Greenwich investigation is 1167. If there should be no truth whatever in the assumed proper motion in the Solar System in space, we might expect $\frac{1167}{4}$, or 291 cases, in which the observed proper motions and the computed effects of parallactic displacement would have the same signs in both elements. On an inspection of the books of calculation I find

that we have 523 such cases of agreement. The excess of 523 above 291 or 232 would appear, therefore, to be the number of cases in which the direction of the proper motion in quadrant has been determined by the effect of the parallactic displacement due to the motion of the Solar System in space. This number is, I should consider, quite sufficient to prove the reality of the assumed solar motion in space. If from 1167 we subtract the probable number of cases of unforced agreement, viz. 291, we have 876 cases remaining. If the effect of the parallactic displacement was as often greater as less than the absolute proper motion, we should have had 138 cases of forced agreement out of these 876 cases, or 729 favourable cases in all. We have, however, only 523 such favourable cases. The inference would appear to be that the effect of parallactic displacement is much oftener less than greater than the absolute proper motion. If the parallactic displacement is less than the absolute proper motion in the ratio of 3 to 4, we should have 219 forced cases out of 876. Our number of favourable cases would then be 510. This is about the number actually obtained. I consider, therefore, that without appealing to the mere agreement of different investigations in the position of the apex of solar motion we have from the results of the Greenwich investigations numerical evidence of the truth of the assumed solar motion in space. The effects of parallactic displacement arising from this motion appear, however, to be on the average much smaller than the independent proper motions of the stars.

Note on the Calculation of the Sun's Parallax from the Lunar Theory by P. A. Hansen. By E. J. Stone, Esq.

In the *Monthly Notices* of the Society, vol. xxiii. No. 8, and vol. xxiv. No. 1, will be found two papers by Professor Hansen, in which values of the Solar Parallax are deduced from the value of $\frac{a}{a_1}$ employed in the construction of his Lunar Tables. In the first paper the adopted value of $\frac{a}{a_1}$ is afterwards multiplied by 1·03573, the factor by which Professor Hansen found it necessary to multiply his computed value of the coefficient of parallactic inequality in order to make his theory agree with observation.

The value of $\frac{a}{a_1}$, thus corrected, is then multiplied by Hansen's constant of Lunar Parallax, 3419″·57. The value of the Solar Parallax thus deduced is 8″·97. The method pursued would appear equivalent to assuming that a is what is generally understood by the semi-axis major of the Lunar Orbit, that is, the semi-axis major, as deduced from the mean sidereal

time of revolution of the Moon. In the second paper the corrected value of $\frac{a}{a_1}$ is employed to determine the ratio of the Moon or the Earth to that of the Sun. With the ratio thus found, the length of the seconds pendulum, and the length of the sidereal year, the value of the solar parallax is deduced.

The equation employed for the determination of the ratio of mass of Earth to that of Sun is

$$\frac{a}{a_1} = \sqrt[3]{n^2 \frac{M + m}{M + m_1}}$$

where M, m, and m_1 are the mass of Earth, Moon, and Sun respectively. The ratio of $\frac{m}{M}$ is assumed $= \frac{1}{80}$. In the text a is spoken of as the semi-axis major, and in the notes n is stated to be $\frac{\text{Earth's Mean Motion}}{\text{Moon's Mean Motion}}$. If, however, we should understand by this that the mean motions are referred to fixed axes, we should find $8''\cdot97$ for the value of the Solar Parallax: the same value as that found in Professor Hansen's first paper. On reference, however, to Professor Hansen's theory it will be found, that if n denote what Hansen calls the mean motion and a the semi-axis major, n denotes the mean motion relatively to the apse, and a is obtained from n by a forced relation similar in form to that given by Kepler's third law,—

$$n^2 a^3 = k (M + m).$$

This appears also from the numerical value of log n, assumed by Hansen, viz., 8·8775917. This being so understood, we obtain not $8''\cdot97$ but $8''\cdot916$. The value $8''\cdot916$ can be obtained at once from the corrected value of $\frac{a}{a_1}$. At page 4 of Hansen's *Lunar Theory* we are given the adopted value of $\log \frac{D}{a} =$ 8·2170139. Now $\log \frac{a}{a_1} = 7\cdot4187223$, hence $\log \frac{D}{a_1} = 5\cdot6357362$ $=$ log sin π, and therefore $\pi = 8''\cdot916$.

The importance of Hansen's result is so great that I have thought it worth while to call attention to the slight want of precision in the notes appended to Hansen's second paper, more especially as we might be led by those notes to an erroneous result more likely to deceive from its agreement with the result given by Professor Hansen himself in his first paper. It may be mentioned that there is a printer's error on page (10) of Professor Hansen's second paper,

For 1·03973 *read* 1·03573.

Determination of a slightly corrected Value of the Solar Parallax from the data of Le Verrier's Solar Tables. By E. J. Stone, Esq.

In Tome iv. of the *Annales de l'Observatoire Impérial de Paris, Recherches Astronomiques*, page 101, will be found a determination of the Sun's mean horizontal equatoreal Solar Parallax by M. Le Verrier. The method adopted is to determine from observation the coefficient of the parallactic inequality in the Earth's motion, and thence by a comparison of the theoretical expression with the observed value to deduce the Sun's Parallax. The value of the coefficient thus found by M. Le Verrier is 6″·50. The Solar Parallax π is then found from the equation

$$\pi = 0\cdot01662 + 6\cdot50 \left\{ 1 + \frac{1}{\mu} \right\},$$

where μ is the ratio of the Moon's mass to that of the Earth.

To determine μ M. Le Verrier adopts the constant of nutation $= 9''\cdot23$, and the constant of (Lunar Solar) precession $= 50''\cdot3714$. He then obtains the following equation,—

$$\mu = \frac{2\cdot1866}{(3422)^3} \frac{\pi^3}{m''},$$

where m'' is the ratio of the mass of the Earth to that of the Sun.

M. Le Verrier adopts for

$$\log \frac{\pi^3}{m''} \text{ the value } 8\cdot35199,$$

and thence deduces $\mu = \frac{1}{81\cdot84}$. This gives $\pi = 8''\cdot95$ and $m'' = \frac{1}{314000}$. There is, however, a slight mistake in the numerical work, which alters the value of μ, and consequently also those of π and m''. I find, adopting the same data

$$\mu = \frac{1}{81\cdot48}, \quad \pi = 8\cdot91, \quad m'' = \frac{1}{317590}$$

That so slight a change in the Moon's mass should alter the resulting value of the parallax $0''\cdot04$ shows the weak point in this method of determining the Solar Parallax. If we adopted a value of the Moon's mass equal to $\frac{1}{78\cdot4}$ of that of the Earth, we should deduce Encke's value $8''\cdot58$ of the Solar Parallax. The coefficient of the parallactic inequality is undoubtedly very accurately determined, and is entirely free from any suspicion of systematic error arising from an erroneous assumption of telescopic semi-diameter; a suspicion which must weaken our

confidence in the value (of Solar Parallax) deduced from the corresponding inequality in the Lunar Theory. The agreement of the value, thus deduced, with those lately obtained by other methods proves the consistence of our adopted values of the constant of Solar Parallax, Nutation and Precession.

Solar Eclipse of March 5, 1867. Observed at the Royal Observatory, Edinburgh. By C. Piazzi Smyth, Astronomer Royal for Scotland.

The Solar Eclipse of March 5th (Astronomical) had its commencement—as seen from here—quite concealed by thick clouds; the middle, partly clear; and the end, entirely so.

The end of the eclipse was observed with the Playfair Alt-Azimuth instrument at $22^h\ 38^m\ 38^s{\cdot}7$ Edinburgh Mean Time; Mr. Fox Talbot being the observer at the telescope, and the time being noted for him by myself.

Several small photographs of the later phases of the eclipse were taken by Mr. W. H. Davies, member of the Edinburgh Photographic Society,—at 89 George Street in this city; I have the honour to inclose one of the most interesting which he has kindly sent me.

In a letter just received from M. Otto Struve, he states that the eclipse was well observed at Poulkova; but that a party whom he had sent on the line of the annular features in the government of Nijni Novgorod, had been entirely defeated by bad weather.

Eclipse of the Sun, 1867, *March* 5, *and Occultation of a Star by the Moon*, 1867, *Jan.* 16; *observed at the Royal Observatory, Greenwich.*

(*Communicated by the Astronomer Royal.*)

Eclipse of the Sun.

The time of the beginning of the eclipse was observed as follows: clouds prevented further observation.

Mean Solar Time of beginning of Eclipse. d	h	m	s	Instrument.	Observer.
March 5	20	17	35·12 (*a*)	North Equatoreal	E.
„	20	17	28·52	46-inch detached	C.
„	20	17	34·02	36-inch detached	L.
„	20	17	31·29 (*b*)	Great Equatoreal	J. C.

(*a*) Clouds passing; the Sun's limit continually obscured: at the time noted the Moon's limb was first seen, and the eclipse had probably begun not many seconds.

(*b*) Uncertain to a second: probably too late by that quantity.

The initials E., C., L., J. C., are those of Mr. Ellis, Mr. Criswick, Mr. Lynn, and Mr. Carpenter.

Occultation of a Star by the Moon.

Day of Observation.	Phenomenon.	Moon's limb.	Mean Solar Time. h m s
1867, Jan 16.	Aldebaran, disapp.	Bright.	7 25 9·9.

The observer was Mr. Carpenter; he stated that the time noted is uncertain to a second, owing to the wind making it difficult to hear the clock; the sky was also cloudy, and the star faint; but the disappearance was instantaneous.

A Catalogue of "New Stars." By G. F. Chambers, Esq.

In compiling my Catalogue of Uncalculated Comets I was very much embarrassed in consequence of the Chinese chroniclers having intermingled with their comets proper a number of objects specifically termed by them "new stars." In some cases it was tolerably clear from internal evidence that these "new stars" were veritable comets, but in others it was impossible to express a confident opinion. Some of these uncertain objects were added to the cometary list, and others were wholly passed over, without, I am constrained to admit, any definite rule being conformed to. This manifestly involved serious drawbacks, and on due reflection, conceiving that it would be convenient to astronomers to possess a comprehensive catalogue of all recorded temporary stars, I decided to detach from the comets all objects which certainly were not comets and unite them with all objects which certainly were stars. The two lists, that is to say, this one and that on p. 352 of my *Descriptive Astronomy* between them, comprise, it is supposed, every comet of which an unequivocal record has been handed down to us. I cannot, however, assert that this list is equally exhaustive in regard to the temporary stars. Let it be understood, therefore, that whilst the Comet Catalogue probably contains no stars, this, most likely, does contain some comets.

I have not included objects which are commonly, and on sufficient authority, dealt with as Variable Stars and usually included in Variable Star Lists, such will be found elsewhere.

The references cited as 'Biot' are to E. Biot's lists published in the *Connaissance des Temps* for 1846. The more notorious temporary stars I have not professed to speak of at length, as they are described in most books on Astronomy. For the sake of completeness, however, it was necessary to allude to them.

133 B.C.

In July an extraordinary star appeared near β, π, ρ *Scorpii*.—(Biot.) Perhaps identical with the comet of 134.

76 B.C.

In October an extraordinary star appeared between α and δ *Ursæ Majoris.*—(Biot.)

101 A.D.

On Dec. 30, a small yellowish-blue star appeared in the group α γ η ζ κ *Leonis* (Biot); as no mention is made of any change of position it may have been merely a temporary star. (Hind's *Companion to the Almanac*, 1859, p. 12.)

107.

On Sept. 13, a strange star appeared to the S.W. of δ ε η *Canis Majoris.*—(Biot.)

123.

In December–January an extraordinary star was seen in the region near α *Herculis* and α *Ophiuchi.*—(Biot.)

173.

On Dec. 10 a star appeared between α and β *Centauri* and remained visible eight months; it was as large as a mat of bamboo and presented in succession five different colours.—(Biot.)

290.

In May a strange star was observed within the Circumpolar regions.—(Ma-tuoan-lin.)

304.

In May–June an extraordinary star was seen in the *Hyades.* —(Biot.)

369.

From the 2nd to the 7th Moon an extraordinary star was visible in the western boundary of the circle of perpetual apparition. The 2nd Moon commenced about March 25, and the 7th about August 20.—(Biot.)

386.

Between April and July a strange star was seen in λ μ ψ *Sagittarii.*—(Biot Gaubil.)

389 ±.

A star blazed out near α *Aquilæ* as bright as *Venus.* It lasted only three weeks.—(Cuspianus.)

393.

Between March and October a strange star appeared in the division of μ^2 *Scorpii.*—(Biot.)

533.

On March 1, a great star appeared.—(Ma-tuoan-lin.) There are no further particulars.

561.

On Oct. 8, an extraordinary star was seen within division of α *Crateris*.—(Biot.)

577.

Pontanus (*Hist. Gelr.* iii.) dates the appearance of a comet in the year that the son of Chilperic died, consequently in 577. Pingré thinks that it is the object recorded by Gregory of Tours as having appeared in the middle of the Moon on Nov. 11, during the celebration of the vigils of St. Martin, and probably a meteor.—(*Comét.* i. 323.)

827 (?).

The year is very doubtful. The Arabian Astronomers, Haly and Ben Mohammed Albumazar, observed at Bagdad a star in *Scorpio* for 4 months. It was as bright as the Moon in its quarters.

829.

In November an extraordinary star was seen in ζ θ ο π *Canis Minoris*.—(Biot.)

945.

A new star was seen near *Cassiopeia*.—(Leovilius, *De Conjunctionibus magnis*.)

1011.

On Feb. 8 an extraordinary star was seen near σ τ ζ ψ *Sagittarii*.—(Biot.)

1012.

From May to August (it would seem) a star was visible in *Aries*. It was of astonishing size and dazzled the eye. It varied in size, and sometimes it was not seen at all. It lasted 3 months.—(Hepidannus, *Annales*.)

1054.

On July 4, an extraordinary star appeared to the S. E. of ζ *Tauri*. It disappeared at the end of the year.—(Biot.)

1139.

In this year an extraordinary star appeared in the division of κ *Virginis*.—(Biot.)

1174 ±

An immense star shone by night and by day in the W. It was surrounded by numerous others all bright red in colour. (Boethius, *Hist. Scot.* xiii.) No doubt a meteor.—(Pingré.)

1203.

Between July 28 and August 6 an extraordinary star was seen in the S. E. in the division μ^2 *Scorpii.* The colour was bluish-white resembling *Saturn.*—(Biot.)

1264.

A new star was seen in the vicinity of *Cassiopeia.*

1572.

In Nov. 1572 a new star became visible in *Cassiopeia,* it lasted till March 1574.

1584.

On July 1 a star appeared in the division π *Scorpii.*—(Biot.)

1604.

A new star appeared in *Ophiuchus;* at one time it was as bright as *Venus.* It was first seen on October 10, 1604, and last seen about the middle of October 1605. Its known duration was therefore about 12 months; but inasmuch as it was lost in consequence of coming into conjunction with the Sun its real duration might have been fourteen or fifteen months. At any rate in March 1606 it had become invisible.

Junior Carlton Club,
London, April 11, 1867.

In the *Ast. Nach,* No. 1629, is contained a paper by Prof. Schiaparelli, "Sur la Relation qui existe entre les Comètes et les Etoiles filantes."

After referring to his letters to Padre Secchi published in the Bulletins of the Observatory of Rome, he reproduces the results as to the August meteor, see *Monthly Notices,* pp. 133–134. He remarks: "In the writings referred to, the position of the Radiant Point of the November meteors had been taken as the point determined by the American observations of 1833,

viz. γ *Leonis*, which is erroneous by several degrees. The new calculation, compared with Dr. Oppolzer's elements of the comet *Ast. Nach.* 1624, the perihelion passage being reduced to Milan Mean Time is—

	Meteors, 13th Nov.	Comet I, 1866.
Perihelion passage	Nov. 10, 092	Jan. 11, 160
Longitude of Perihelion ...	56° 25′ 9″	60° 28′ 0″
Node ...	... 231 28 2	231 26 1
Inclination ...	... 17 44 5	17 18 1
Perihelion distance	... 0·9873	0·9705
Excentricity ...	... 0·9046	0·9054
Semi-axis major	... 10·340	10·324
Revolution ...	... 33·250 years	33·176
Motion ...	... retrograde	retrograde

where it is assumed, 1°, the time of max. of the meteors is Nov. 13 13^h 11^m Greenwich M.T.; 2°, the position of the radiant point, long. 143° 12′, lat. N. 10° 16′; 3°, period 33·25 years (Newton). The position of the radiant point is that determined by Mr. Herschel, *Monthly Notices*, vol. xxvii. p. 19; but taking the longitude 145° instead of 143° 12′, the discrepancy of 4° in the longitude of perihelion would be made to disappear." M. Schiaparelli asks, Are the meteors to be considered as swarms of minute comets, or as the products of the dissolution of large comets?

On the Orbit of the November Meteors. By Prof. J. C. Adams.

It is known to the President and to several members of the Society that I have been for some time past engaged in researches respecting the November Meteors, and allusion is made to some of my earlier results in the last Annual Report. As my investigations are now in some measure complete, and the results which I have obtained appear to me important, I have thought that they may not be without interest for the Society.

In a memoir on the November Star Showers, by Professor H. A. Newton, contained in Nos. 111 and 112 of *The American Journal of Science and Arts*, the author has collected and discussed the original accounts of 13 displays of the above phenomenon in years ranging from A.D. 902 to 1833.

The following table exhibits the dates of these displays, and the Earth's longitude at each date, together with the same particulars for the shower of November last, which have been added for the sake of completeness.

No.	A D.	Day and hour.	Earth's longitude.
		d h	° ′
1	902	Oct. 12 17	24 17
2	931	14 10	25 57
3	934	13 17	25 32
4	1002	14 10	26 45
5	1101	16 17	30 2
6	1202	18 14	32 25
7	1366	22 17	37 48
8	1533	24 14	41 12
9	1602	27 10 O.S.	44 19
10	1698	Nov. 8 17 N.S.	47 21
11	1799	11 21	50 2
12	1832	12 16	50 49
13	1833	12 22	50 49
14	1866	13 13	51 28

From these data Professor Newton infers that these displays recur in cycles of 33·25 years, and that during a period of two or three years at the end of each cycle a meteoric shower may be expected. He concludes that the most natural explanation of these phenomena is, that the November Meteors belong to a system of small bodies describing an elliptic orbit about the Sun, and extending in the form of a stream along an arc of that orbit which is of such a length that the whole stream occupies about one-tenth or one-fifteenth of the periodic time in passing any particular point. He shows that in one year the group must describe either $2 \pm \frac{1}{33\cdot 25}$, or $1 \pm \frac{1}{33\cdot 25}$, or $\frac{1}{33\cdot 25}$ revolutions, or, in other words, that the periodic time must be either 180·0 days, 185·4 days, 354 6 days, 376·6 days, or 33·25 years.

It is seen that the time of the year at which the meteoric shower takes place becomes gradually later and later, and that accordingly the Earth's longitude at that time, or the longitude of the node of the orbit of the meteors, is gradually increasing. Professor Newton finds that the node has a mean motion of $102''\cdot 6$ annually with respect to the Equinox, or of $52''\cdot 4$ with respect to the fixed stars; and he remarks that since the periodic time is limited to five possible values, each capable of an accurate determination, and since therefore from the position of the radiant point the other elements of the orbit can be found, it seems possible to compute the secular motion of the node for each periodic time with considerable accuracy, and the actual motion of the node being known, we have thus an apparently simple method of deciding which of the five periods is the correct one.

Soon after the remarkable display of these meteors in November last, I undertook the examination of this question. From the position of the radiant point as observed by myself, I calculated the elements of the orbit of the meteors, starting

with the supposition that the periodic time was 354·6 days, the value which Professor Newton considered to be the most probable one. The orbit which corresponds to this period is very nearly circular, and it readily follows from the ordinary theory that the action of *Venus* would produce an annual increase of about 5″ in the longitude of the node, and that of *Jupiter* an annual increase of about 6″. The calculation of the motion of the node due to the Earth's action, presented greater difficulty in consequence of the two orbits nearly intersecting each other. I succeeded, however, in obtaining an approximate solution, applicable to this case, from which it followed that the Earth's action would produce an annual increase of nearly 10″ in the longitude of the node. Thus the three planets above mentioned which alone, in the case supposed, sensibly affect the motion of the node, would cause a motion of about 21″ annually, or nearly 12′ in 33·25 years. It has been already mentioned that the observed motion of the node is 52″·4 annually, or about 29′ in 33·25 years. Hence the observed motion of the node is totally irreconcilable with the supposition that the periodic time of the meteors about the Sun is 354·6 days. If the periodic time were supposed to be about 377 days, the calculated motion of the node would differ very little from that in the case already considered, while, if the periodic time were a little greater or a little less than half a year, the calculated motion of the node would be still smaller. Hence, of the five possible periods indicated by Professor Newton, four are entirely incompatible with the observed motion of the node, and it only remains to examine whether the fifth period, viz. one of 33·25 years, will give a motion of the node in accordance with observation.

The calculations which have been above described were entirely founded on my own determination of the radiant point. In order to have as secure a basis as possible for the subsequent calculations, I adopted for the position of the radiant point the mean of my own and five other determinations, partly taken from published documents and partly privately communicated to me. These determinations are as follows, the several authorities being placed in alphabetical order:—

	R.A. °	′	Decl. °	′	
Adams	148	50	22	10	N.
Baxendell	149	33	22	57	
Brünnow	150		22		
Challis	149	39	23	12	
Herschel	148	9	23	48	
Herschel A.	149		24		
Mean	149	12	23	1	N.

Or with reference to the ecliptic,

Long. 143° 22′ Lat. 9° 51′ N.

Starting from this position of the radiant point, and the assumed period, and taking into account the action of the Earth on the meteors as they were approaching it, I obtained the following elliptic elements of their orbit:—

Period	33·25 years (assumed)
Mean distance	10·3402
Excentricity	0·9047
Perihelion distance	0·9855
Inclination	16° 46′
Longitude of Node	51 28
Distance of Perihelion from Node	6 51
Motion Retrograde	

In order to determine the secular motion of the node in this orbit, I employed the method given by Gauss in his beautiful investigation "*Determinatio attractionis &c.*"

It may be proved that if two planets revolve about the Sun in periodic times which are incommensurable with each other, the secular variations which either of these bodies produces in the elements of the orbit of the other would be the same as if the whole mass of the disturbing body had been distributed over its orbit in such a manner that the portion of the mass distributed over any given arc should be always proportional to the time which the body takes to describe that arc. In the memoir just referred to, Gauss shows how to determine the attraction of such an elliptic ring on a point in any given position. When this attraction has been calculated for any point in the orbit of the meteors, we can at once deduce the changes which it would produce in the elements of the orbit, while the meteors are describing any given small arc contiguous to the given point. Hence, by dividing the orbit of the meteors into a number of small portions, and summing up the changes corresponding to these portions, we may find the total secular changes of the elements produced in a complete period of the meteors.

In this manner I have found that during a period of 33·25 years, the longitude of the node is increased 20′ by the action of *Jupiter*, nearly 7′ by the action of *Saturn*, and about 1′ by that of *Uranus*. The other planets produce scarcely any sensible effects, so that the entire calculated increase of the longitude of the node in the above-mentioned period is about 28′.

As already stated, the observed increase of longitude in the same time is 29′. This remarkable accordance between the results of theory and observation appears to me to leave no doubt as to the correctness of the period of 33·25 years.

In order to attain a sufficient degree of approximation it is requisite to break up the orbit of the meteors into a considerable number of portions, for each of which the attractions of the elliptic rings corresponding to the several disturbing planets have to be determined; hence the calculations are necessarily very long, although I have devised a modification of Gauss's formulæ which greatly facilitates their application to the present problem. In these numerical calculations I have been greatly aided by my assistants, more especially by Mr. Graham. I am now engaged in obtaining a closer approximation by subdividing certain parts of the orbit of the meteors into still smaller portions, but the results which have been given above cannot be materially changed.

Since I entered upon the foregoing investigation other astronomers have been led, on totally independent grounds, to conclusions which strongly confirm, and are confirmed by, those at which I have myself arrived.

In the *Bullettino Meteorologico dell' Osservatorio del Collegio Romano*, vol. v. Nos. 8, 10, 11, 12, are published four letters from Sig. Schiaparelli, Director of the Observatory of Milan, "*Intorno al corso ed all' origine probabile delle Stelle Meteoriche.*" In these letters the author arrives at the conclusion that the orbits which the meteors describe about the Sun are very elongated, like those of comets, and that probably both these classes of bodies originally come into our system from very distant regions of space. In his last letter, dated 31st Dec. 1866, Sig. Schiaparelli shows that if the August Meteors be supposed to describe a parabola, or a very elongated ellipse, the elements of their orbit calculated from the observed position of their radiant point, agree very closely with those of the orbit of Comet II. 1862, calculated by Dr. Oppolzer. The following table exhibits this agreement:—

	August Meteors.	Comet II. 1862.
Perihelion distance	0·9643	0·9626
Inclination	64° 3′	66° 25′
Longitude of Perihelion	343 28	344 41
Longitude of Node	138 16	137 27
Direction of Motion	Retrograde	Retrograde

Hence it appears probable that the great Comet of 1862 is a part of the same current of matter as that to which the August Meteors belong.

In the letter which has just been referred to, Sig. Schiaparelli likewise gives approximate elements of the orbit of the November Meteors, calculated on the supposition that the period is 33·25 years; but as the calculations were founded on an imperfect determination of the radiant point, these elements were not sufficiently accurate, and Sig. Schiaparelli

failed to find any cometary orbit which could be identified with that of the meteors.

Soon after this, on the 21st January, 1867, M. Le Verrier communicated to the Academy of Sciences a theory of the origin and nature of shooting stars, very similar in its main features to that of Sig. Schiaparelli, and at the same time gave more accurate elements of the orbit of the November Meteors, his calculations being based on a better determination of the radiant point than that employed by the astronomer of Milan.

In the *Astronomische Nachrichten*, of the 29th January, Mr. C. F. W. Peters of Altona pointed out that the elements given by M. Le Verrier closely agreed with those of Tempel's Comet (I. 1866), calculated by Dr. Oppolzer, and on the 2nd February, Sig. Schiaparelli, having recalculated the elements of the orbit of the meteors on better data than before, himself noticed the same agreement.*

Dr. Oppolzer's elements of Tempel's comet are as follows:—

Period	33·18 years
Mean distance	10·3248
Excentricity	0·9054
Perihelion distance	0·9765
Inclination	17° 18′
Longitude of Node	51 26
Distance of Perihelion from Node	9 2
Direction of Motion	Retrograde.

If these elements be compared with those of the November Meteors which I have given in a former part of this communication, it will be seen that their agreement is remarkably close.

The curious and unexpected resemblance which is thus shown to exist between the orbits of known comets and those of the meteors, both of August and November, opens a wide field for speculation. It is difficult to believe that the coincidences which have been noticed are merely accidental; but whether or not we are disposed to adopt the ideas of Sig. Schiaparelli as to the intimate relations between meteors and comets, I cannot help thinking that my researches respecting the motion of the node of the November Meteors have settled the question as to the periodic time of these bodies beyond a doubt.

* See *ante*, p. 246.—*Ed.*

Errata in two papers of the Astronomer Royal.

Communicated by the Astronomer Royal.

It has been pointed out to me by William Mann, Esq., of the Royal Observatory, Cape of Good Hope, through Sir Thomas Maclear, that one of the observations made at Greenwich on the Solar Eclipse of 1860, July 18, is recorded with an error of 1′. The observation in question is on page 64 (last paragraph) of the *Greenwich Observations* 1860, in the column "Readings of Microscopes, M," where

for 68° 50′ 42″·6 *should be read* 68° 49′ 42″·6

Omitting various intermediate steps, the results of this correction are as follows:—

Monthly Notices, vol. xxi. p. 157. (March 8, 1861, No. 5.)

Near the top of the page.

For	− 38″·63	*read*	− 38″·45
	− 8·75		− 8·58
	− 1·45		− 1·06
	− 2·97		− 2·40

At the bottom of the page,

For	− 1·1	*read*	− 0·95
	− 4·0		− 3·78
	+ 0·3		+ 0·64
	− 2·4		− 1·80

Monthly Notices, vol. xxv. p. 264 (Supplemental Notice, No. 9.)

Line 21, *for* − 3″·0 *read* − 2″·4.

Royal Observatory, Greenwich,
March 27, 1867.

Errors in Tables of Logarithms. By A. D. Wackerbarth.

In reading the proof-sheets of a small table of 5-place logarithms against other works of the same kind, I have met with the following errors in accredited tables:—

Shortrede's *Tables*, p. 205.

Log. (1, 2, 3, 4 . . . 20,) *for* 18·38612642 *read* 18·38612442*

* By a note of General Shortrede's, it appears that this correction is incomplete; the last three figures, instead of 642 should be 462—the figures 4 and 6 having been transposed.—*Ed.*

Bremiker's *Nova Tabula Berolinensis.*

sin. 1° 17′ 41″	*for*	4027	*read*	4017
sin. 3 29 45		5169		5159
46		5203		5193
47		5238		5228
48		5272		5262
49		5306		5296
cos. 12 11 20		0198		0098

At 85°. 4′, the 4′ is missing in the argument.

Multiples of 2·302585 *for* 40 \| 82·103404 *read* 40 \| 92·103404

Vega's 10-place Tables, *Thesaurus Completus*, p. 655, in the 48-place hyperbolic logarithms.

Log. 1099 *for* 7·0021 1595 &c. *read* 7·0021 5595, &c.

Tables published by Taylor and Walton, London, 1839, under the Superintendence of the Useful Knowledge Society,

p. 213 l. 5 *for* 2·718281829 *read* 2·718281828,

(the following figure being 4.) This is the only error I know of in this beautifully printed little table.

P. Barlow's *Mathematical Tables*, London, 1814, in the table of 8-place hyperbolic logarithms,

Pag. 217	Log 1099	*for*	7·0021 1595	*read*	7·0021 5595
	1197		7·0877 5371		7·0875 7371
	1319		7·1841 4155		7·1846 2915
	1388		7·2356 2914		7·2356 1914
218	1943		7·5718 8845		7·5719 8845
	1934		7·5673 3568		7·5673 4568
	1992		7·5968 9544		7·5968 9444
219	1537		7·3375 2774		7·3375 8774
	1919		7·5596 0950		7·5595 5950
220	2464		7·8095 1132		7·8095 4132
223	2905		7·9742 8867		7·9741 8867
224	3402		8·1321 7877		8·1321 1877
226	3683		8·2114 6292		8·2114 8292
227	3675		8·2092 0841		8·2093 0841
	3736		8·2258 7080		8·2257 7080
228	4204		8·3438 9173		8·3437 9173
231	4736		8·4629 618		8·4629 4618
232	5291		8·5736 6254		8·5737 6254
233	5426		8·5199 5749		8·5989 5749
237	6395		8·7633 7171		8·7632 7171
	6349		8·7560 2260		8·7560 5260

Page 241	Log. 7125	*for* 8·8713 6500	*read* 8·8713 6501
245	8278	9·0213 1667	9·0213 5667
247	8936	9·0975 4334	9·0978 4334
	8827	9·0854 7049	9·0855 7049

Stegmann's *Tafel der Naturlichen Logarithmen*, Marburg, 1856.

Log. 2989	*for* 369	*read* 269
3325	923	922
4873	146	147

It is perhaps as well to remark, that, as the table on which I was myself engaged is a 5-place table, errors that do not affect the 5th decimal will have escaped my notice.

Upsala, March 4, 1867.

Comet I. 1867.

Discovered at Marseilles, January 27, 1867, by M. Stéphan.

The following elements calculated by Dr. Oppolzer from observations at Marseilles, January 27, Leipzig, February 4, and Josephstadt, February 9, are given *Ast. Nach.* No. 1631:—

$$T = 19{\cdot}70995 \text{ January, Berlin M.T.}$$

$$\left.\begin{aligned} \pi &= 74^\circ\ 32'\ 26''{\cdot}5 \\ \Omega &= 77\ \ 22\ \ 59\ {\cdot}5 \\ \iota &= 18\ \ 33\ \ 38\ {\cdot}7 \end{aligned}\right\}\text{Mean Equinox, } 1867{\cdot}0.$$

$$\log q = 0{\cdot}208288$$

Representation of the mean observation,

$$d\lambda \cos\beta = +\ 0''{\cdot}3$$
$$d\beta = -\ 5\ {\cdot}1$$

the elements on account of the smallness of the latitudes of the comet being somewhat uncertain.

Erratum.

No. V, p. 191, line 5. In "Diameter of disk calculated and observed," *fo* inches *read* seconds of arc.

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// MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

Vol. XXVII. *May* 10, 1867. No. 7.

Rev. Charles Pritchard, President, in the Chair.

James Whatman Bosanquet, Esq., Claysmore, Enfield,
John Joynson, Esq., Waterloo, Liverpool,

were balloted for and duly elected Fellows of the Society.

On the Distribution of the Nebulæ in Space.
By Cleveland Abbe, Esq.

Those who realise the incompleteness of our knowledge of the positions and nature of the so-called Nebulæ, and the illusory nature of any conclusions generalized from our scanty stock of facts, are agreed as to the need of more systematic, thorough observations of both celestial hemispheres. In view of the important additions to our knowledge of these bodies to be expected when the results of Lassell's observations at Malta are published, and when Grubb's 4-foot mirror, Cooke's 25-inch, and Clark's 18-inch objectives (combined with spectra analysis), have yielded us whatever revelations they have to make from their respective stations at Melbourne, Funchal, and Chicago, it might be expected that one would defer any speculations to a future time.

The publication in 1864 of Sir John Herschel's *General Catalogue of Nebulæ and Clusters of Stars*, enabled me some two years ago to attempt to gain some knowledge of the laws of the apparent distribution of these bodies; some of the most obvious of which had been already indicated in the "Results

of Astronomical Observations made at the Cape of Good Hope." If the present Note be found to present nothing new to the generality of those conversant with this field of research, its results may still be worthy of notice as being drawn from the study of a larger number of objects and a more systematic classification of them than seems to have been made the basis of previous opinions.

The investigation of Sir John Herschel above mentioned treats of the distribution of 3812 Nebulæ and Clusters visible to the 18½-inch reflector, as mounted successively at Slough and at Feldhausen, and its accompanying plate exhibits the grouping of these objects in quadrilaterals whose sides are 1 hour in R.A. and 15° in N.P.D. The General Catalogue of 1864 contains 5079 numbers, of which several represent more than one object, but as several numbers have been perhaps intentionally omitted, we may consider this as being very nearly the number of objects catalogued.

In order to obtain merely a general view, all these objects were arranged in groups whose sides were 30^m in R.A. and 10° in N.P.D. The summation of these groups gave 5076 as the number of objects represented; the accidental errors that may have crept into the process are considered as insignificant. The positions of the *Via Lactea* and the *Nubeculæ* having been indicated by heavy lines enclosing the proper quadrangles, a careful scrutiny sufficed to show that the *Nubecula Major* (N.M.) and the *Nubecula Minor* (n.m.) are distinct groupings, independent of each other and isolated from the *Via Lactea* (V.L.) Neither are these to be considered as centres of condensation for the general system of objects represented, which, on the contrary, exhibit a very decidedly increasing condensation as we approach the poles of the *Via Lactea* (R.A. $0^h\ 47^m$ N.P.D. 64°, and R.A. $12^h\ 47^m$ N.P.D. 116°).

The paucity of Nebulæ and abundance of Clusters within the neighbourhood of the *Via Lactea* have been before noticed; but it suggested itself as a subject of inquiry whether or no the stellar nature of this band of light, as resulting from the studies of the Herschels and Struve, could not be further corroborated by the present investigation.

A second table, showing the distribution of the Clusters, was now prepared, in which a distinction was made between the ordinary clusters (Cl.) and the globular ones (⊕). 637 objects were here represented, and their condensation in the *Via Lactea* and the *Nubeculæ* became very obvious.

A third table was added showing the distribution of the resolved or resolvable Nebulæ (marked *r*, *rr*, *rrr*, in Sir John's Catalogue). In this table were included those globular clusters (⊕) marked *r*, *rr*, or *rrr*; these may, as a general rule, be considered as coming in respect to ease of resolvability between the ⊕ and the resolved or resolvable nebulæ; of the ordinary clusters (Cl.) only two are marked as *r* (resolved) as

an indication of the closeness of their constituent stars. 397 resolvable Nebulæ present themselves in this table, of which 12 only are within the borders of the *Via Lactea*.

Finally, a fourth tabular view was prepared, and is herewith presented (see Table, pp. 260–261), showing the distribution of all remaining objects, that is, the unresolved Nebulæ, of which 64 lie within the *Via Lactea*. 4053 objects are found in this table, but it should contain 4042 if the previous numbers are correct; the agreement of these numbers shows the sufficient accuracy of the numerical processes.

In the accompanying arrangement of the unresolved Nebulæ the horizontal lines represent the meridians distant $0^h\ 30^m$ of R.A. from each other, beginning at $0^h\ 0^m$; the vertical lines represent the circles distant 10° of N.P.D. from each other, beginning at 0°. The heavy lines inclose the *Via Lactea* and the *Nubeculæ*. The secant of the middle of each zone is given at the bottom of the Table.

Besides the zone whose average breadth of 10° here represents the *Via Lactea*, use has been made of a still broader zone, symmetrical therewith but 30° wide, and which may be supposed to include within it many objects belonging to the Gallactic System, but comparatively nearer us than the faint stars forming that band.

The following Table exhibits the general character of the distribution of the 5076 objects. The column "Area" gives the approximate relative areas of the divisions of the apparent celestial sphere for two cases; first, when the Lacteal band is taken to be 10° wide; second, when it is taken 30° wide.

Distribution of Nebulæ and Clusters.

Via Lactea 10° broad.

	Area.	All Objects.	Cl.	⊕	⊕ r	Neb r.	Neb.
North of V.L.	18	2787	150	8	23	262	2351
In V.L. ...	3	349	254	6	13	12	73
South of V.L.	13	1552	76	13	22	80	1356
In N.M. ...	$1\frac{1}{2}$	350	52	0	14	36	248
In n.m. ...	$\frac{1}{2}$	38	3	3	0	7	25
Sum	36	5076	535	30	72	397	4053

Via Lactea 30° broad.

	Area	All Objects.	Cl.	⊕	⊕ r	Neb. r.	Neb.
North of V.L.	15	2496	20	3	12	246	2215
In V.L. ...	8	767	434	14	29	35	255
South of V.L.	11	1425	26	11	16	73	1299
In N.M. ...	$1\frac{1}{2}$	350	52	0	14	36	248
In n.m. ...	$\frac{1}{2}$	38	3	3	0	7	25
Sum	36	5076	535	31	71	397	4042

Arrangement of all objects not classified as "Cl.", "⊕", or Resolvable Nebulæ in Sir John Herschel's General Catalogue, 1864.

h m to h m	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
0 0 to 0 30		1			1	6	19	5	10	4	4	2	8	5	6	1	2	
0 30 — 1 0					4	13	7	3	16	15	4	3	9	4	7	1	15	
1 0 — 1 30		1				56	2	3	24	17	2	2	24	5	6	1	8	
1 30 — 2 0		1		2	1	17	14	11	10	8	4	5	8	3	5	3	2	
2 0 — 2 30			1		5	14	2	9	3	13	10	4	6	6		1		
2 30 — 3 0	1				11	11	2	5	7	9	12	1	3		4	1		
3 0 — 3 30		1			16	2			2	17	9	11	15	1	3	2		
3 30 — 4 0			1	1		2	1	1		9	8	10	12	11	2	5	1	
4 0 — 4 30			1	1		2		1	3	13		4	3	10	17	4		
4 30 — 5 0									6	33	3	3	3	3	3	37	9	
5 0 — 5 30			1			2	2			10	4	4	7	3	2	80	16	1
5 30 — 6 0								1	1	3	3	4	1		8	58	24	1
6 0 — 6 30			1				1	1		5		7	3	2	3	18	6	
6 30 — 7 0				6	1	8		1	1	2	2	7		2		3		
7 0 — 7 30			2	1		6	3	1	3	1	1	2						
7 30 — 8 0				20	2	1	6	2	4		5	2		1	1	2	1	
8 0 — 8 30				7	1	1	10		2		3	4	1			1		1
8 30 — 9 0		6	2	11	6	8	8	7	2	11	1	1		2	2			
9 0 — 9 30	1	1	7	8	8	26	9	10	3	1	10	11	2	1	2	5	1	
9 30 — 10 0	1	10	6	4	10	11	7	12	6	8	11	18	6				1	
10 0 — 10 30	4	6	4	13	13	7	25	4	6	1	4	10	23	5	2	3	1	1
10 30 — 11 0		11	7	11	7	11	14	25	12		7	12	7	3	3			
11 0 — 11 30		5	7	23	9	7	26	23	6	6	10	5	10		2	6	1	
11 30 — 12 0		5	8	36	19	19	67	29	9	7	14	6	3	1	2	1		

h m to h m	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
12 0 to 12 30		12	17	23	23	31	32	91	76	13	7	2	4	2				
12 30 13 0		7	1	16	11	18	36	22	39	45	21	7	11	26				
13 0 13 30		3	3	15	16	30	9	21	16	10	20	22	10	12		1		
13 30 14 0	1	3	11	23	23	29	5	4	22	12	3	8	6	5	1			
14 0 14 30	1	4	2	13	11	27	14	10	29	7	3	3	1	6	1			
14 30 15 0		2		9	18	13	4	3	23	4	8		1	2		1	2	
15 0 15 30		2	3	·12	13		3	7	7	3	3	2		1	1	1		
15 30 16 0		2	2	5	4	2	1	7	4		1	1	1				1	
16 0 16 30		3	1	5	9	12	2						7	3		2	1	
16 30 17 0	2	1	3	1	2	5	3								1		1	
17 0 17 30		3	4	1	2		1	1			1	3	5		2	4		
17 30 18 0		2	5				1	3	1	2		9	1			6		1
18 0 18 30		1	1	1		1		1	1	1	3	1	3			3	2	
18 30 19 0					1	1						1			6	11		
19 0 19 30						1			2	1			2	2	6	6	2	
19 30 20 0				2		1	1		1		1	1	1	6	8	2		
20 0 20 30						2		1	1	2	1		2	8	4		5	1
20 30 21 0			1		1	3	1	2		6	1		2	8	6	3		
21 0 21 30			1					1	3	1			2	11	2	2		
21 30 22 0			2		2	1	2	1			3	7	14	11	9	7	2	
22 0 22 30					1	5	2	2			6	8	10	4	1	3		
22 30 23 0			1	1		9	5	14	12	2	4	9	6	10	1	4		
23 0 23 30			2		3	1	5	21	22	14	2	1	5	7	6	6		1
23 30 0 0			2			3	5	8	18	3	1		3	2	1	3		
Secant	11·5	3·9	2·4	1·7	1·4	1·2	1·1	1·0	1·0	1·0	1·0	1·1	1·2	1·4	1·7	2·4	3·9	11·5

The study of the foregoing Tables may lead to the following conclusions or suggestions:—

1. The Clusters (Cl.) are members of the *Via Lactea*, and are nearer to us than the average of its faint stars.

2. The Nebulæ resolved and unresolved lie in general without the *Via Lactea*, which is therefore essentially stellar.

3. The visible universe is composed of systems, of which the *Via Lactea*, the two *Nubeculæ*, and the Nebulæ, are the individuals, and which are themselves composed of stars (either simple, multiple, or in clusters) and of gaseous bodies of both regular and irregular outlines.

Confining our attention to the Nebulæ, we might conceive their paucity in the immediate neighbourhood of the *Via Lactea* to be partially due to the comparative glare of the intervening multitude of stars; but their persistent paucity when the limits of that band are supposed greatly increased (to $\frac{8}{36}$ of the entire celestial surface) implies that the Nebulæ are actually either fainter or scarcer, that is, less condensed, in the neighbourhood of that plane, or that the visible universe is less extended in that direction. As the gradual successive increase in the powers of our telescopes has not revealed to us many new faint nebulæ in this band, we may be led to consider that these instruments have brought to view the great portion of the existing nebulæ that lie apparently near the plane of the *Via Lactea*, and that this plane cuts nearly at a right angle the axis of a prolate ellipsoid, within whose surface all the visible nebulæ are uniformly distributed.

From this point of view results that the *Nubeculæ* are merely nebulæ accidentally near to us, and we have to inquire concerning the position of the Sun, or rather of the *Via Lactea*, with reference to the 4134 (= 2613 + 85 + 1436) other nebulæ.

Let d be the distance from the Sun (S) northwards to the centre (C) of the supposed prolate ellipsoid of revolution, whose semiaxes are a and b. The volume of the ellipsoid is $2\,V = \frac{4}{3}\pi\, a\, b^2$; that of the section between planes through S and C, parallel to the *Via Lactea*, will be

$$V' = \frac{4}{3}\pi\, a\, b^2 \left(\frac{3}{4} - \frac{1}{4}\frac{d^2}{a^2}\right)\frac{d}{a}.$$

The volume on the south side of the Sun is therefore

$$V - V' = V\left(1 - \frac{3}{2}\frac{d}{a}\ldots\ldots\right);$$

that on the north side is however

$$V + V' = V\left(1 + \frac{3}{2}\frac{d}{a}\ldots\ldots\right).$$

Therefore, assuming an uniform distribution throughout, we have

$$\frac{V - V'}{V + V'} = \left(1 - 3\frac{d}{a}\ldots\ldots\right) = \frac{1436 + 42}{2613 + 43} = \frac{5}{9} \text{ nearly,}$$

$$\text{whence } \frac{d}{a} = \frac{4}{27}.$$

This result is essentially dependent upon the assumption that our telescopes have made visible all the nebulæ of mean brightness within the distance $a + d$.

The ratio $\frac{d}{a}$ may be also obtained from a comparison of the apparent densities at the north and south poles of the universe; the volumes of the visual cones extending from S to these poles are in the ratio $\left(\frac{a-d}{a+d}\right)^3$ which becomes $= \frac{53}{456}$ if we examine circles of 15° radius about each pole, whence $\frac{d}{a} = \frac{1}{3}$.

Both of the above resulting values for d are to be modified by the consideration that much more powerful telescopes have been used in the northern than in the southern hemisphere, and the satisfactory solution of all questions as to the distribution of Nebulæ in space must await a new general survey of the heavens with one and the same instrument, successively stationed at different latitudes and under similar atmospheric conditions.

The preceding results will also be modified if certain hours of Right Ascension have been less carefully surveyed than others; an examination of the sweeps made with the 20-foot reflector has however failed to reveal any important omission in this respect as regards Sir John Herschel's observations.

With respect to the relative distances of the Nebulæ from us it may be remarked that, if the order of distance be in general represented by the progression — Clusters, globular Clusters, resolvable globular Clusters, resolvable Nebulæ, Nebulæ — then will the results given by Mr. Huggins on p. 383 of the *Phil. Trans.* for 1866 be represented by the assumption that light undergoes in its nature some modification in passing through immense distances of imperfectly elastic ether, as well as by the assumption that a certain proportion of nebulæ are gaseous, as distinguished from others which are aggregations of glowing solid or liquid globes. But this latter seems too plausible to be improbable, and receives sufficient confirmation from the apparent association of stellar and gaseous masses in the same Nebula. Now it may be remarked that the General Catalogue contains 34 planetary nebulæ (○) and 4 annular nebulæ (◎); the former of which may be especially said to give optical signs of having a gaseous nature. These bodies follow almost identically the law of distribution given by the Clusters, for we have :—

Distribution of Planetary Nebulæ (O).

	V.L. 10° broad	V.L. 30° broad.
North of V.L.	16	9
In V.L.	9	21
South of V.L.	9	4
	34	34

Whence, in accordance with the previous views, the planetary Nebulæ may be classed with the Clusters as regards their arrangement and distance from us, and are to be considered as the gaseous globes belonging to our *Via Lactea*, which therefore retains its character as essentially a stellar Nebula, forming with the *Nubeculæ* and the 4100 $(= 262 + 12 + 80 + (2351 - 16) + (73 - 9) + (1356 - 9))$ Nebulæ, the entire visible universe.

It will perhaps be sufficient if, without advocating the correctness of the previous conclusions, we are led to undertake any rational course of systematic investigation. The questions as to the spectra of the planetary Nebulæ, the resolvability of the Nebulæ in the neighbourhood of the *Via Lactea*, and the condensation of Nebulæ around the poles of that band, seem worthy of special study.

January 1867.

On the Estimation of Star Colours. By Sidney B. Kincaid, Esq. (Abstract.)

The author remarks that with the exception of the two isolated instances of *Sirius* and 95 *Herculis*, the latter of them due to the researches of the late Admiral Smyth and the Astronomer Royal for Scotland, no crucial example of the change of the colour of a star has been determined; although there is every reason to believe that such objects vary as well in their hues as in their apparent brilliancies. That Physical Astronomy, which has made such strides in relation to the "Variables," has done so little in the matter of sidereal chromatics is certainly not owing to any lack of interest on the part of the latter subject of inquiry, but is owing to the difficulties that beset any attempt at accurate chromatic observation. Until the publication of the late Admiral's last work, which was specially devoted to the "Colours of Double Stars," no general system for reducing such observations to permanent record in connexion with perpetual standards of comparison had been introduced; and although a great step was taken by the suggestion to use a universally recognised scale of colours as a point of reference—for which aim was given a chromic plate in the book,—coupled with the mentioned use by Mr.

Huggins of chemical solutions as such standards, many hindrances were left remaining, and in the great loss by Admiral Smyth's death shortly afterwards was probably included much further progress towards their removal.

The only instrumental means described by him, the photometrical measurement of the spectrum of the star so as to determine the lucidity of its different sections, is objectionable, as well by reason of its exceeding dependence on the occurrence of opportunities of weather, not only "fine," but "superlatively fine," as by reason of the great and numerous difficulties which render the application of it almost impracticable. The object of the author is to describe an apparatus for the purpose of determining star colours, by which the tints of the fixed stars may be exactly recorded relatively to standards easily reproducible by any observer, with any kind of telescope, any number of years hence, and that by a contrivance the manipulation and reading of which is as easy as the plans now usually adopted for photometric estimations. But he first recapitulates the causes of error which particularly belong to this kind of research. These are—

1st. Personal Equation :—including therein three heads, which, although properly so described as belonging entirely to the personality of the observer, are actually distinct, viz.:—A. That insensibility of the eye to the varieties of colour, which in its most extreme form is colour-blindness. B. Inability of the memory to retain exactly the impression produced by a certain tint, so as to be capable of reproducing and identifying it at a subsequent period. C. Personal difference in the habit of describing the impression of a particular colour.

2nd. Atmospheric Equation :

3rd. Instrumental Equation. Good achromatic refracting telescopes are open to little imputation of deceit as regards the exhibition of the colours of celestial objects; but the case is far otherwise with reflectors. The prevalence of excessive redness among Sir W. Herschel's chronicles of sidereal chromatics has long given rise to the opinion that the speculum metal misled him in this respect; and in the same way, silvered glass mirrors are not (without due correction) reliable in any case where the colour of an object is to be accurately depicted.

4th. Standard of comparison. The requisites in such are that it shall afford the exact shade of colour of the star in connexion with which it is to be used, so that such tint shall be easily reproducible with precision by any observer at a future time from the information transferred by the ordinary use of language and that it shall be suitable for comparison with telescopic images. A painted scale like that given in *Sidereal Chromatics*, by Admiral Smyth, is, on account of its opacity of colour, objectionable, and can scarcely claim to be considered sufficiently reproducible. Precious stones, though in many respects suitable, are plainly beyond the reach of most

observers; and the only system which appears to possess the requisite qualification is that of chemical solutions before referred to.

The "Metrochrome," which it is the author's object to describe, is shown in side-section and by a face-view in two figures given in the original paper. It consists essentially of three parts: 1st. A lantern for the production of a constant light; 2nd. A contrivance for imparting to that light the necessary colour, and so arranged that the proper tinge once produced, a record of it can be obtained so as to enable its reproduction at any time; 3rd. Apparatus to throw that coloured light into the field of the telescope as an artificial star which can thus be viewed side by side with the image of the real one. The source of light is a very fine platinum wire, rendered incandescent by a current of electricity transmitted through it from a Smee's battery of two cells. The platinum wire is brought into the focus of a lens so that the rays of light from the lantern issue parallel, and therefore come to a focus, after passing through the object-glass of the telescope, at the same distance from it as those emitted by a star. The chromographic part of the apparatus consists of a drum rotating about an axis. The drum has in it six equidistant radial openings; the alternate three of them transmitting the normal light of the lantern; the other three constructed so as to admit flat-sided stoppered bottles containing chemical solutions of different colours. The outer edge of each of the last-mentioned apertures is graduated into ten parts, and each of them can be wholly or partially closed by means of a radial shutter; the other three apertures can be simultaneously closed, wholly or partially, by a triune radial shutter; the edge of one of them is divided into ten parts, and as all are equally affected by the movement of the shutter, the reading applies to the three openings. The drum is made to rotate so as to bring successively the different apertures in front of the lantern; and, when the rotation is sufficiently rapid, the impression of colour produced on the retina of the eye will be that of a colour compounded of the colours of the solutions in the three alternate apertures, diluted by the white light transmitted through the other three alternate apertures. By a proper selection of the solutions and adjustment of the magnitude of the several apertures by means of the shutters, it will be possible to produce the exact colour of a particular star; and then the record of the solutions employed, and of the dimensions of the several apertures, will enable the exact reproduction of such colour at any future period, for comparison with the then colour of the star in question. The remaining part of the apparatus is a contrivance for throwing the beam of coloured light into the telescope, so as to produce, as already mentioned, the image of an artificial coloured star.

Addition to Second Note on the Lunar Theory.
By Prof. Cayley.

Writing as in my Second Note, *Monthly Notices*, Vol. xxv, pp. 203–207 (May 1865), for the Moon,

a, the mean distance,

e, the excentricity,

γ, the tangent of the inclination,

l, the mean longitude,

c, the mean anomaly,

g, the mean distance from node,

I obtained by the ordinary method of the variation of the elements, from the constant term of R and the term involving $\cos(2c-2g)$, the following expressions of the variations,

$$\delta a = 0$$

$$\delta e = -\frac{5}{8}\gamma^2 e \cos 2c-2g$$

$$\delta \gamma = +\frac{5}{8}\gamma e^2 \quad ,, \quad 2c-2g$$

$$\delta c = +\frac{5}{8}\gamma^2 \quad \sin 2c-2g$$

$$\delta g = +\frac{5}{8}e^2 \quad ,, \quad 2c-2g$$

$$\delta l = +\frac{5}{16}\gamma^2 e^2 \quad ,, \quad 2c-2g$$

viz. if in the elliptic expressions of the radius vector, longitude, and latitude, we apply to a, e, γ, c, g, l, the foregoing increments, we obtain to the fourth order in (e, γ) the portions independent of m in the expressions of the radius vector, latitude, and longitude. I wish to notice that the results, to the very limited extent to which they go, agree with those obtained by M. Delaunay in his "Théorie du Mouvement de la Lune," from his 49th operation, the object of which is to take away the term (63) of R, that is the term involving $\cos(2c-2g)$. The formulæ (see vol. i. p. 788), taken only to the necessary degree of approximation are

$$\begin{array}{lcl}
a & \text{replaced by} & a \\
e^2 & ,, & e^2 - 5\ \gamma^2 e^2 \cos 2g \\
\gamma^2 & ,, & \gamma^2 + \frac{5}{4}\gamma^2 e^2\ ,,\ 2g \\
l & ,, & l - \frac{5}{2}\gamma^2\ \sin 2g \\
h+g+l & ,, & h+g+l+\frac{5}{4}\gamma^2 e^2\ ,,\ 2g \\
h & ,, & h + \frac{5}{8} e^2\ ,,\ 2g
\end{array}$$

which, observing that

$$\begin{array}{ll}
\gamma\ (\text{Del.}) & = \frac{1}{2}\gamma\ (\text{for present purpose}) \\
l & = c \\
g+l & = g \\
h+g+l & = l \\
\text{and } \therefore g & = -(c-g)
\end{array}$$

become

$$\begin{array}{lcl}
a & \text{replaced by} & a \\
e^2 & ,, & e^2 - \frac{5}{4}\gamma^2 e^2 \cos 2c - 2g \\
\gamma^2 & ,, & \gamma^2 + \frac{5}{4}\gamma^2 e^2\ ,,\ 2c-2g \\
c & ,, & c + \frac{5}{8}\gamma^2\ \sin 2c - 2g \\
l & ,, & l - \frac{5}{16}\gamma^2 e^2\ ,,\ 2c-2g \\
l-g & ,, & l-g-\frac{5}{8}e^2\ ,,\ 2c-2g
\end{array}$$

the last of which may be changed into

$$g\quad ,,\quad g + \frac{5}{8}e^2\quad ,,\ 2c-2g$$

or if the new values of a, e, γ, c, g, l, are called $a+\delta a$ $e+\delta e$, $\gamma+\delta\gamma$, $c+\delta c$, $g+\delta g$, $l+\delta l$, then the increments δa, δe, $\delta\gamma$, δc, δg, δl, have the values given above. The process of my Second Note, taken as a first transformation, has in fact the object of removing the term cos $(2c-2g)$, and to the degree of approxi-

mation regarded, the result is not affected by the previous transformations, or by the substitution, t. ii. p. 800, introducing for a, e, γ, their standard elliptic values.

Notes on some Drawings of Mars, made during the recent Opposition. By John Browning, F.R.A.S.

The thirteen coloured drawings of *Mars* I have now the pleasure of exhibiting to the Society were made with Mr. Barnes' 8½-inch silvered-glass reflector. They represent the planet as it appeared on Dec. 29th, 1866, at $9^h\ 30^m$ G.M.T.; on Jan. 8th, 1867, at $9^h\ 1^m$; Jan. 28th, at 9; on Jan. 28th, at 12.30; on Feb. 6th, at 8.15; on Feb. 6th, at 11.30; on Feb. 8th, at 8.30; on Feb. 8th, at 10.30; on Feb. 16th, at 6.45; on Feb. 23rd, at 8.45; on Feb. 23rd, at 10.30; and on Feb. 24th, at 1 A.M. Achromatic eye-pieces were used; generally the power was about 300, but occasionally I have used as high as 600.

I have shown these drawings to Mr. De La Rue, who had no trouble in matching two of them with his own two exquisite drawings of the planet. Mr. De La Rue's drawings which were taken by the aid of his 13-inch metal speculum of his own make, contain more detail than my own drawings, but Mr. De La Rue expressed his opinion that my drawings were valuable from the number I had succeeded in obtaining.

I have made nearly thirty sketches at the telescope, but I have copied only those that were made when the air was tolerably steady, and the definition so good that I could work well with high powers. When several sketches were made on the same evening, they were made at intervals of two hours, if the weather permitted. In only one instance have I failed to perceive that the form of the markings was permanent, due allowance being made for the effect of perspective in foreshortening them as they approached the edge of the disk.

It is highly probable that in the view of the planet taken on Feb. 16th, at 6.45, the two pointed markings on the extreme left, one above and the other below the equator, would have been seen united if they could have been observed when they were on the centre of the disk. This drawing would then have agreed pretty closely with one of Mr. Dawes' views engraved in the *Astronomical Register*, for Sept. 1865.

The colour of the body of *Mars* I have found vary from rose-madder to burnt-ochre, the colour appearing ruddiest when there was most mist in our atmosphere. The comparative absence of the ruddy colour towards the edges of the disk of the planet, Mr. Norman Lockyer has ascribed to the presence of clouds in the planet's own atmosphere.

Mr. Huggins, in his valuable paper on the "Spectrum and the Colour of *Mars*" (*Monthly Notices*, March 8, 1867), has referred the absence of colour at the edges of the planet, to some peculiar effect of the surface of the planet itself.

That the ochreish colour is due to some peculiarity in the surface is, I think, almost proved by Mr. De La Rue's drawings of *Mars*, as in these are seen markings of an ochreish colour with definite outlines.

The colour of the dark markings on *Mars* has been described as greenish or bluish-gray. They always appear bluish-gray to me, and this colour I have depicted them. Occasionally the North Polar ice has been shown tinted with the same colour.

I have examined the spectrum of the planet with a direct-vision spectroscope. The spectrum of the dark markings presented no distinctive peculiarity. This would scarcely prove the entire absence of a blue or green shade of colour in the markings, as I have found that if white light be reflected five or six times from surfaces of metallic silver, and then received on white paper, it will be strongly tinged with a chocolate colour. Yet if the light reflected from paper thus illuminated be examined by means of a spectroscope, no appreciable difference will be seen between the spectrum of this light and that of white light. In consequence of the effect of irradiation, I have not been able to make out satisfactorily the outline of the North Polar ice.

I have frequently seen faint white spots appear on the disk, and as these spots approached the edge of the disk they increased in brilliancy, until when nearly at the extreme edge of the disk, they almost rivalled the polar snows in whiteness. The white cloudy patches had never any definite outlines. They were generally nearly circular in form, and they always appeared in the region of the equator. One of these white cloudy spots I have shown in the sketch taken on Feb. 8th, at 10.30. The spot is represented passing off the left-hand edge of the disk.

Mr. De La Rue has shown the dark markings near the south pole as darkest towards the edge nearest to the centre of the planet, and just below the edge of the dark markings the ruddy colour of the body as much fainter than it is nearer to the equator.

I see these appearances distinctly.

In the drawing taken on Jan. 28th, at 9^h, a number of breaks will be seen in the edge of the dark marking near the south pole; these breaks forming a series of light streaks directed towards the pole. Mr. Barnes made a sketch at the telescope without seeing mine, and as with the exception of a slight difference in the angle given to these light streaks, the two sketches agreed, I cannot have been mistaken in their appearance having been as I have drawn and described them.

On the 31st of March, at 7 P.M., I obtained an exact repetition of the position shown in the sketch taken on Feb. 23rd, at 9 P.M.

In these two drawings the mark usually termed the hourglass mark, is represented as having just passed the centre of the disk of the planet.

This would give a velocity of revolution to the planet agreeing within 44″ with Beer and Madler's determination.

Mr. Barnes has made sketches corresponding with nearly all my drawings, and agreeing with them in all the general features.

A Determination of the Coefficient of the Parallactic Inequality, and a Deduction of the Value of the Sun's Mean Horizontal Equatoreal Parallax from the Greenwich Lunar Observations 1848–1866. By E. J. Stone, Esq. (Abstract.)

The longitudes deduced from the observations made near the maximum of the Parallactic Inequality are compared with the tabular longitudes; and (it being assumed that the error in the mean results arises entirely from error in the coefficient of the parallactic inequality) the comparison furnishes a correction to the coefficient in question, and consequently also to the value of the Solar Parallax used in the calculation of that coefficient. The result, as deduced from in all 2075 observations, is that the coefficient of the Parallactic Inequality is $= 125''\cdot36$; and that the corresponding value of the Solar Parallax is $= 8''\cdot850$, with a possible error not greater than $\pm\ 0''\cdot056$ in the parallax, arising from an assumed uncertainty $0''\cdot4$ in the theoretic value of the coefficient of the inequality, and an assumed uncertainty of the same amount in the value of the coefficient as obtained from the Observations.

On the Mass of the Moon as deduced from the Mean Range of Spring and Neap Tides at Dover during the years 1861, 1864, 1865, *and* 1866. By H. P. Finlayson, Esq.

The determination is effected by means of the following equation:—

$$(19\cdot192)^2 : (15'\ 43''\cdot76)^3 + \frac{(16'\ 1''\cdot82)^3}{x} :: (10\cdot939)^2 : (15'\ 30'')^3 - \frac{(16'\ 1''\cdot82)^3}{x}$$

viz. 19·192 feet is the mean range of the spring-tides for the

four years, 10·939 the mean range of the neap-tides; 15′ 43″·76 and 16′ 1″·82 the mean semidiameters of the Moon and Sun respectively at the spring-tides, 15′ 30″ and 16′ 1″·82 the mean semidiameters at the neap-tides; x is the density of the Moon, that of the Sun being taken $= 1$; the equation gives $x = 2{\cdot}218$ leading to the value, Moon's mass $= \frac{1}{87{\cdot}925}$ of the Earth's mass. The values obtained by effecting the determination in the same manner for each of the four years separately are $\frac{1}{89{\cdot}870}$, $\frac{1}{88{\cdot}243}$, $\frac{1}{87{\cdot}943}$, and $\frac{1}{86{\cdot}000}$ of the Earth's mass.

Errata in Logarithmic Tables of 1849.
By Major-General Shortrede.

In the log. of cub. in. dist. water in grains there is in some copies an obvious error. I have a copy properly corrected, and by some mistake it has been made wrong again.

The following list of Errata in the Log. Tables of 1849 is supplementary to the one given in the January number of 1864, page 68, vol. xxiv. They were omitted to be given along with the others owing to the copy in which they were noted having been mislaid, and out of reach; the unauthorised issue in 1844 contains several others.

Preface p. viii	line	Δ_7 *for*	20200	*read* 20160 ∇_8			
xvi		16	9426	9428		**For.**	**Read.**
		18	1670	1672	& in log	8833	8837
		19	7182	7184			
				P_1 / p_1		4211	4215
In Tables 31	in log	24451	2996	2966			
50	Diff. & Mult. 91 × 8		729	728			
Logs 36	log	54033	6541	6591	This correction has been recently communicated by M. Leverrier through the Astronomer Royal.		
67		67951	1959	1958			
81		85071	6815	7815			
Antilogs 146		41799	8124	8123	These and the great majority of the errors in the Antilogs formerly noted were communicated by Mr. Gray.		
178		79689	4512	4552			
184		86588	3119	3109			
188		92052	7683	7603			

In the formulæ for Spherical Triangles

Case	Sought		
598 2 sides & ∠ opp	C	*for* $\cot\xi$	*read* $\cos\xi$
	c	$\frac{\cos b\cos\phi}{\cos b}$	$\frac{\cos a\cos\phi}{\cos b}$

In the Table of Constants

R°	last 5 fig	*for* 25025	82320 8	from an error of 1 in the summation.
Sin 1°	7	17275 54	37283 51	
Log Sin 1°	4	1831	2286	These were detected by Capt. Jacob.
Sin 1″	2	68	76 3677	
tan 1″	7	15233 63	1334 436	
Sin 1ᵍ	2	675 4	575 4	
Sin 1ᵗ		*after* 01570 *insert* 796		

The correction of the error on page 205 in log (1.2.3...20) for 642 read 442 is incomplete; the proper correction is, *for* 642 *read* 462—the figures being transposed.

Additional Remarks on the Solar Eclipse of Nov. 6, 1867. By A. Brothers, Esq.

In my letter of March 7 I said that the image of the Sun was "remarkably *steady*" during the whole time of the eclipse. The word was printed "*shady*," and consequently the meaning of the sentence was destroyed.

The state of the atmosphere is referred to in most of the notices of the late eclipse as being the reverse of what it was here. In this fact will perhaps be found the explanation that the irregularities of the Moon's limb were not seen by some observers, while others saw them distinctly. My attention was chiefly devoted to photographic experiments, but I saw sufficient to enable me to say that the rough outline of the Moon was distinctly seen. There was a small spot on the Sun not far from the centre of the disk, and it was so distinct that I have been surprised to read that observers with far larger instruments than my own report the entire absence of any spot.

Manchester,
6th May, 1867.

Occultation of Mercury by the Moon. By Capt. W. Noble.

The planet was wretchedly defined, the sky was hazy, and the sunlight bright. *Mercury* seemed to fade away gradually. He finally seemed to disappear absolutely at

$$1^h\ 34^m\ 28^s \text{ L.S.T.} = 22^h\ 54^m\ 55^s \text{ L.M.T.}$$

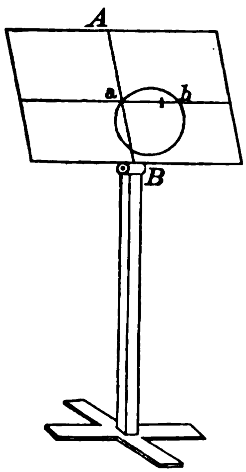
B

The Moon's limb was utterly invisible. Power employed 74, or my 4·2 inch Equatoreal of 61 inches focal length.

Forest Lodge, Maresfield,
May 1867.

On a Plan for Fixing the Position of Solar Spots. By E. D. Ashe, Commander R.N., Director of the Observatory, Quebec.

Not remembering that Mr. Carrington had given in the *Monthly Notices* a plan of fixing the position of a spot upon the Sun's disk, I devised a mode of doing so for myself; and, as I think that it is simple and suited to the smallest telescope, I dare say it may be useful.

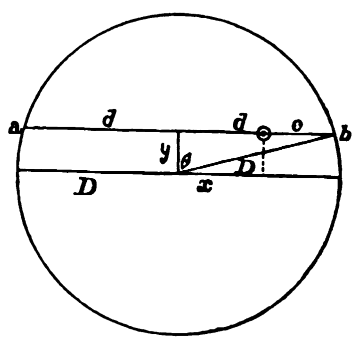


Any telescope that has an equatorial stand is first placed with its polar axis (as near as you can guess) parallel to the axis of the Earth; you then place a screen, having two lines drawn at right angles to one another, in such a position that the spot will move along one of them.

Move the telescope so that the Sun is well to the right of the line *A B*.

Mark the time by a watch that the limb (*a*) cuts the line *A B*, and also the time that the spot is bisected, and, lastly, the time that the following limb (*b*) cuts the line *A B*.

You have got by these three simple observations all that is required.



Take half the time of describing the chord (*a b*), and call it (*d*).

Take the number of seconds between the spot and limb (*b*), and call it (*c*).

Then, as the time of the Sun's semidiameter passing the meridian is given in the *Nautical Almanac*, page 1, we have *D* given, and then

$$d - c = x \quad . \quad . \quad . \quad . \quad . \quad (1)$$

$$\frac{d}{D} = \sin\theta$$

$$D\cos\theta = y \quad . \quad . \quad . \quad . \quad . \quad (2)$$

N.B. Mean time is turned into Sidereal time by adding $0^s{\cdot}18$ to the time of Sun's passing the meridian.

The advantage of not requiring any "wire frame" in the telescope is very great.

EXAMPLE.

June 1, 1866.

$$\left.\begin{array}{l} d = 65^s{\cdot}5 \\ c = \;\; 7{\cdot}0 \\ D = 68{\cdot}4 \end{array}\right\} \quad \begin{array}{r} 65{\cdot}5 \\ -\;7{\cdot}0 \\ \hline 58{\cdot}5 \end{array} = x;\; y = 19{\cdot}71.$$

65·5	1·81624	cos θ .	9·45968
68·4	1·83505		1·83505
sin θ .	9·98119	y =	1·29473 19·71

Comet II. 1867.

Discovered by M. Tempel 3d April, 1867—

R.A. = 225° 45′ Decl. S. = 2° 27′.

The following elements, calculated by Dr. Peters from the original observation of April 3, observations at Leipzig and Berlin, 12 April, at Berlin 21 April, and Hamburg 25 April, are given *Ast. Nach.* No. 1638:—

T = 1867, Feb. 27·88264, Berlin M.T.

$$\left.\begin{array}{lcl} \pi & = & 162^\circ\ 40'\ 17'' \\ \Omega & = & 168\ \ 35\ \ 31 \\ \iota & = & 6\ \ \ 7\ \ \ 0 \end{array}\right\} \text{App. Equinox, April 21.}$$

Log q = 0·05090.

Motion direct.

Observations of Comet II. 1867. By C. G. Talmage, Esq.

I beg to enclose observations of Comet II. (Tempel's) made at this Observatory.

	G.M.T.	Comet's R.A.	Comet's Decl.	No. of Obs.
	h m s	h m s	° ′ ″	
1867, April 29	12 3 10·21	15 7 56·43	− 1 56 49·80	3
30	12 0 37·81	15 7 53·00	− 1 59 5·4	3
May 1	11 20 21·14	15 7 44·27	− 2 1 29·4	3
3	12 29 18·01	15 7 22·92	− 2 7 50·5	5
4	10 16 21·22	15 7 10·90	− 2 10 53·8	5
5	10 13 40·52	15 6 59·00	− 2 14 34·4	5
6	11 10 30·32	15 6 46·80	− 2 19 4·3	3

The comparison star from April 29 to May 3 was *Weisse Hora* 15, No. 119, and for May 4, 5, and 6, *Weisse Hora* 15, No. 125.

On May 4 the Comet was very faint and difficult of observation, through clouds.

On May 3, with a power of 250, the nucleus appeared to me to have a division across its centre.

The power used for all the measures was 130, with dark field and illuminated wires.

RECENT PUBLICATIONS.

Uebersicht der Thätigkeit der Nicolai-Hauptsternwarte während der ersten 25 *Jahre ihres Bestehens; zusammengestellt von Otto Struve*. 4to. St. Petersburg, 1865, pp. 1–119.

The history of the foundation of the Pulkova Observatory is given in the *Description de l'Observatoire Astronomique central de Poulkova* (1845); and the part which the Emperor Nicholas personally took therein is more fully shown in a smaller work by the late W. Struve, at the time when after the death of the founder, the Institution, by command of the present Emperor, assumed its present designation. The objects of the foundation are, in the Statute of 14 June, 1838, declared to be—

(*a*) To furnish without intermission, and as perfectly as possible, Observations for the furtherance of Astronomy as a science;

(*b*) To set on foot corresponding observations for geographical undertakings in the Empire, and scientific explorations;

(*c*) As far as possible to contribute to the perfecting of

Practical Astronomy in its applications to Geography and Navigation, and to afford opportunities for the practice of the determination of geographical positions. And in a subsequent paragraph the obligation is imposed upon it, as a central Institution, to exercise a control over the works undertaken by the remaining Observatories of the Empire, so that science may derive therefrom the greatest possible benefit. And these are substantially the objects under the present statute, formally confirmed on the 14th August, 1862, but which has been partly in operation since the year 1857. By this statute the staff was augmented, the Institution placed directly under the Minister of Public Instruction, and a "Comité" instituted analogous to the Greenwich Board of Visitors.

The volume contains notices of the Personal of the Institution; it is mentioned that Mr. Otto Struve is the only one of the officials who has been in the Observatory uninterruptedly from its foundation. The directorship of W. Struve, in his full vigour, continued till the year 1857; during the next two years, on his partial retirement from commencing ill health, Mr. Otto Struve was Vice-Director; and upon his final retirement in 1861, Mr. Otto Struve became Director. The bulk of the volume is occupied with a survey of the work of the Observatory during the 25 years under the three heads,—I. Astronomy; II. Geography and Geodesy; III. Instruction. It concludes with a Catalogue of the published writings of the Pulkova Astronomers during the period in question (1839 to 1864). These include Stellar Astronomy, 1 to 48; Observation and Investigations on the Solar System, 49 to 89; Practical Astronomy, 90 to 103; Geodesy, 104 to 124; Geographical Position-determinations, 125 to 139, and History, Bibliography, Physical Investigations, &c., 139 to 159. It is needless to refer to the many well-known works by W. Struve, O. Struve, Peters, Döllen, Weisse, Winnecke, &c., &c., included in this enumeration.

Annals of the Dudley Observatory. Vol. i. 8vo. Albany, 1866.

The volume contains an account of the foundation of the Institution; a description of the Observatory and Instruments, by G. W. Hough, A.M., the Director; and an Appendix. The establishment of the Institution was first proposed, in 1851, by Dr. J. H. Armsby; a subscription was raised, a large part of which was contributed by Mrs. Blandina Dudley, widow of the Honourable C. E. Dudley, and it was thereupon resolved to give to the institution the name of the Dudley Observatory. The Act of Incorporation was granted by the Legislature of the State of New York, in March, 1852. The building was

completed in 1854, on a site selected by Professor Mitchell, and from plans furnished by him. The Institution was inaugurated on the 28th of August, 1856, at the meeting of the American Association for the Advancement of Science. About 100,000 dollars was expended on the building, instruments, grounds, and other objects; and 50,000 dollars invested as a fund for the support of the Institution. The Observatory is situated in the north-western portion of the city of Albany, on an elevation about 150 feet above the mean tide in the Hudson River—the site being, probably, one of the best that could have been chosen in the vicinity of the city; easy of access, and at the same time remote enough to be free from every disturbing influence. The horizon is clear and unobstructed in every direction; and the position is such as to preclude all possibility of interference if in future years the adjoining lands should be occupied for building purposes. In the plane of the meridian there is an uninterrupted view to the south for more than twelve miles. Advantage has been taken of this for the establishment of two meridian marks, distant six and twelve miles respectively. The grounds comprise about eight acres, and include the whole of the more elevated portion of the hill, which slopes off gradually in every direction. Two lithographic views are given, a distant and a near one; and there is also a plan of the grounds, and a ground-plan of the Observatory.

The principal instruments are,—

Equatoreal Refractor, by Mr. Fitz of New York; the object-glass 13 inches clear aperture; the focal length 15 feet 2 inches;

Olcot Meridian Circle, by Pistor and Martins;

Transit Instrument, by same makers;

Comet Seeker, by Alvan Clark; of 3 feet 6 inches focal length, and 4 inches clear aperture;

Chronograph, invented by Professor Mitchell, made by Messrs. Foster and Twitchet, Cincinnati;

Declinometer, invented by Professor Mitchell, by the same makers;

Charting Machine, made by Mr. Fasoldt, of Albany;

Automatic Registering and Printing Barometer, invented by Mr. Hough;

Swedish Calculating Machine of G. and E. Scheutz, purchased for the Observatory in the year 1856;

all elaborately described in the volume, with perspective views and drawings of the various details.

The Appendix comprises the Act of Incorporation, Board of Trustees, List of Donors, Catalogue of the Library, the Directors' Reports for the years 1862-63-64, and 65: and observations of the Planets *Mars* and *Neptune*, of several of the Minor Planets, and of Comets.

Addition to the Obituary Notice of Dr. Whewell, contained in the last Annual Report, see p. 113.

Among Dr. Whewell's works ought to have been mentioned the invention of an Anemometer for measuring the speed of the wind and registering it with reference to the direction of the wind. This instrument was in use at the Royal Observatory, Greenwich, for several years; till it was superseded by Dr. Robinson's; an instrument of superior mechanical construction and greater accuracy of register, but wanting the valuable indication of direction of the wind.

To be Sold.

The property of a Fellow removing.

A well-constructed wooden Observatory, with revolving polygonal dome, the internal diameter of which is about 9 feet.

Also a completely-mounted 4-inch Cooke Equatoreal on Iron-pillar.

Application to be made to G. F. Chambers, Esq., Junior Carlton Club, 16 Regent Street, W.

ERRATA

in last month's *Monthly Notices*.

Page 240, line 3, *for* Moon or *read* Mass of.

240, in formula, *for* n^2 *read* u^2.

240, line 22, *for* log n *read* log u.

241, *for*

$$\varpi = 0{\cdot}01662 + 6{\cdot}50 \left\{ 1 + \frac{1}{\mu} \right\},$$

read

$$\varpi = 0{\cdot}01662 \times 6{\cdot}50 \left\{ 1 + \frac{1}{\mu} \right\},$$

242, line 5, *for* constant *read* constants.

242, in note (*a*), *for* Sun's limit *read* Sun's limb.

CONTENTS.

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MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

Vol. XXVII. *June* 14, 1867. No. 8.

Rev. Charles Pritchard, F.R.S., President, in the Chair.

Capt. Henry Wood, 16 St. John's Wood Park;
Charles Judd, Esq., Foundation School, Leman Street; and
Commr. Edmund Hope Verney, R.N., Travellers' Club,

were balloted for and duly elected Fellows of the Society.

On Certain Appearances of the Telescopic Images of Stars described by the Rev. W. R. Dawes. By G. B. Airy, Astronomer Royal.

In a paper of unusual value, printed in the *Monthly Notice* of 1867, April 12th, Mr. Dawes has described (page 232) "the curious but annoying tendency which is occasionally seen in the telescopic disks of stars to become triangular, especially when the wind is in the east, or south-east." Mr. Dawes' experimental examinations of this appearance were sufficiently varied to prove that it did not depend on the object-glass of the telescope.

I read Mr. Dawes' description of this phenomenon without surprise; in consequence of the following circumstance.

About thirty-five years ago, I had the pleasure of visiting Sir David Brewster at his residence in the neighbourhood of Melrose. Sir David then described to me the ocular appearance which had for some time annoyed him. As I gathered from his oral account, the appearance was of this kind. The visible field surrounding a luminous object was divided into three equal parts by three lines from the luminous object

making with each other angles of 120° (I think that these were not visible as distinct lines, but are to be taken as imaginary lines dividing the phenomena next to be mentioned), and in each of these angular spaces were coloured curves of hyperbolic character. Sir David Brewster then informed me that he became convinced that these appearances arose from some chronic derangement of the stomach, and that he adopted a cautious medical treatment, and that at length the luminous curves disappeared suddenly.

Sir David Brewster has subsequently published an account of this observation in a paper in the *Transactions of the Royal Society of Edinburgh*, vol. xxiv., part i., afterwards reprinted in the *Philosophical Magazine*, 1865, part i., page 426, and bearing the title "On the Cause and Cure of Cataract." The account of the phenomenon in this paper agrees generally with that which I had heard so long before, although, naturally, it is not so vivid as that which was given in conversation at a time so much nearer to the occurrence.

Some time,—perhaps two or three years,—after this conversation, I saw the appearance myself. It was on an occasion of sorrow, when my whole nervous system was for the time disturbed, and when the eye was moist. It is my impression that in each of the three compartments, I saw two irregular hyperbolas, one surrounding the other.

I have never seen the appearance again. I do not doubt that the appearances noted by Mr. Dawes are of the same ocular class, and that they present themselves only when the nervous system is in some measure deranged. It is scarcely necessary to remark that such derangement very usually accompanies an east wind. In a remarkable instance mentioned by Mr. Dawes, east wind and fatigue were combined.

Another circumstance noticed by Mr. Dawes, page 267, is that at high altitudes stars require a longer focus (that is, the eye requires more convergent rays) than at low altitudes. I imagine this also to be ocular. In looking at a low star, the eye can be directed almost exactly towards the star; but in looking at a high star, it is difficult to direct the eye to a sufficiently great elevation, and the pencil of light will fall low on the retina. It is possible, but I cannot say whether it is certain, that greater convergence of the incident pencil is then necessary for accurate concentration on the retina.

Royal Observatory, Greenwich,
May 20, 1867.

Note on the alleged Change of Focus requisite in observing Stars widely separated in Altitude. By Captain Noble.

On the 10th of May, a discussion took place at the Meeting in reference to an alleged change in the focal length of a tele-

scope adjusted on a star high up in the heavens, when it is turned upon one near the horizon. Since then I have been in communication with my friend Mr. Huggins upon this subject; and, at his instigation, have been experimenting upon stars which differ in colour, as well as in altitude. The night of Sunday last, the 9th inst., was so extraordinarily and exceptionally fine that I determined to devote it to these observations, and the results of them I now beg leave to lay before the Society.

I commenced with *Antares*, upon which I focussed with all possible accuracy. The companion was glaringly visible, and the definition of the primary more perfect than ever I saw it before. Having satisfied myself that the focus was exact, I turned the telescope upon *Vega, which was equally well defined*; no alteration whatever being requisite, nor indeed permissible, in the focus. I now reversed the operation, and, disarranging the eye-piece, refocussed upon *Vega*. Depressing the instrument once more until *Antares* came into the field again I found the same superb image which I had at first beheld and which the slightest motion of the eye-rack only deteriorated.

I then looked at Webb's red star in *Aquila*. It is a 7·5 mag. situated in R.A. $18^h\ 57^m\ 11^s$ and N.P.D. 95° 53′. The focus of this too corresponded with that of other white stars of about the same size. Finally I compared *α Herculis* (which I selected on account of its deep orange tint) with λ *Ophiuchi*; but, as before, the foci were one and the same. It will thus be seen that the results I obtained were wholly negative. Nothing could exceed the magnificence of the definition, *α Herculis* exhibited a single unbroken ring of light, like a golden hair, round the primary, the companion being free from any optical appendage whatever. The two stars might have been cut out of coloured tin and laid upon black velvet, from the appearance they presented.

The powers I employed were 255 and 394 upon my Ross Equatoreal of 4·2 inches aperture, and 61 inches focal length. I tried 154 upon *Antares*, but this was only to assure myself that I could see the *comes* steadily with that power.

If it be difficult to prove a negative, it is not much easier to infer anything from one; but it would seem to me that my observations tend to show that, in the very finest state of the atmosphere, the foci of all stars are identical: but that when, as in the normal state of things, there is an appreciable amount of vapour near the horizon a shortening of the focus of a telescope directed to objects in its neighbourhood may take place; a conclusion in accordance with the views which I orally expressed at our last Meeting.

Forest Lodge, Maresfield, Sussex,
June 14, 1867.

On the Earliest Provable Traces of good Practical Astronomy.
By C. Piazzi Smyth, Astronomer Royal for Scotland.

(*Abstract by the Author.*)

The author,—taking up the method of examining by modern mensuration, the exactness of the contemporary astronomical orientation of ancient buildings,—passes in review the oldest structures of Ethiopia, Egypt, Chaldæa, Assyria, Media, Babylon, Persia, Greece, Etruria, India, Cambodia, and America, in so far as they can claim to be really antique, and to have been well measured recently. He then arranges them into three classes, viz.:—

1st. Those which have no definite astronomical position;

2nd. Those which are oriented, as to the sides of their bases, *diagonally* to the cardinal points; and

3rd. Those which are directed *on* these points.

The 2nd and 3rd classes include all the most ancient buildings examined; and while the diagonal method prevailed generally in Mesopotamia, and culminated in its most splendid example in the temple of Nebo devoted to all the Planets at Babylon,—the direct form characterized the Pyramids of Lower Egypt, of which the Great Pyramid is the typical specimen.

Comparing, then, Sir H. Rawlinson's measures of the orientation of the sides of the Nebo building, with his own made upon those of the Great Pyramid (and which are fully given in an appendix), the author deduces the remarkable result,—that the Pyramid building was oriented by its architect no less than sixty times more accurately than the Babylonian; and yet the Pyramid was earlier by full 1500 years!

Some comparisons then follow on the respective Pyramid and Babylonian systems of metrology, and their influences on ourselves even at the present time.

Note on the Coefficient of Expansion of the Brass Pendula used in the Indian Trigonometrical Survey. By Major J. F. Tennant, R.E.

I had intended to lay before the Meeting an abstract of the proceedings of the Indian Trigonometrical Survey, which Col. Walker the Superintendent asked me to make from his Report, but have been prevented from doing so.

One result has however been announced, so important that I have obtained permission to lay it before you in a less formal way before the Session closes.

Many of you are probably aware that Col. Walker took to India certain brass pendula, the property of the Royal Society,

and a vacuum apparatus for swinging these pendula at a very low pressure of atmosphere. Capt. Basevi (of our corps) was duly instructed in the use of this apparatus, and after a good deal of trouble, got it to work satisfactorily in India. Observations had been taken at several stations, and provisionally reduced, of which the results were lately published in the Proceedings of the Royal Society. But in the Report of which I am now speaking, Col. Walker states that in these reductions there is an anomaly, which at present points to the probability that at a pressure of only 5 inches of mercury the coefficient of expansion of the brass pendulum must be not only increased, but appears to be 13 per cent greater than ever before has been assigned to brass.

I do not suppose any one here anticipated such a result, though we know that in extreme cases the law of expansion varies. The boiling points of fluids depend on the pressure, and so does the melting point of some bodies. Near these critical points the regular progress of expansion changes, and as it is highly improbable that the change commences suddenly, it seems not improbable that the law of uniform progress of expansion with temperature is only an approximation to a far more general law, in which the dimension of every body depends (as we know that of a gas does), but by a complicated relation, on the pressure and temperature, and that by removing $\frac{5}{6}$ths of the pressure, the terms dependent on it may become sensible.

We have been in the habit of considering that the linear dimension is of the form $l + l.\ t.\ \frac{d\,l_0}{d\,t_0} + \frac{1}{2}\,l.t^2.\ \frac{d^2\,l_0}{d\,t_0^2}$ at the utmost. Col. Walker's result, if confirmed, would tend to add a term $l.\ \mathrm{F}\ (t)\ \frac{d^2\,l_0}{d\,t_0\,d\,p_0}$ but if there be such a term, there is a probability that there are coefficients of $\frac{d\,l_0}{d\,p_0}$ and $\frac{d^2\,l_0}{d\,p_0^2}$, which might be sensible to a sufficiently refined investigation, and that the coefficient of $\frac{d^2\,l_0}{d\,t_0\,d\,p_0}$ does not only contain l and t. This is tantamount to a variation of the size of a solid with pressures alone, which has (so far as I know) never been contemplated as recognisable. At the same time, one can hardly conceive that change of pressure shall give the particles of a body so much freedom of motion that the temperature coefficient shall change, without causing a change of size at the same time.

There have, I understand, been some anomalies at Kew, which Mr. Balfour Stewart has not traced to temperature; but it is quite certain, that in the observing season in India, the diurnal range of temperature is far greater than at Kew, and that the effect of a change in the temperature coefficient would be much more marked. Col. Walker will doubtless do what he can with the means at his disposal, but pendula

seem unadapted for investigating this question; and I would hope that some worthy successor of Baily and Sheepshanks, will with special means undertake to investigate a question which is absolutely necessary to complete the theory of pendula and standards of length and capacity.

Recent Observations and Remarks of Hofrath Schwabe regarding Sun-spots and other Solar Phenomena.

Communicated by W. De la Rue, B. Stewart, and B. Loewy.

About two months ago Hofrath Schwabe called our attention to certain phenomena on the surface of the Sun, which he had noticed since last December and which he recollected to have occurred before, but only at the time of a minimum in the number of Sun-spots. The phenomena are:—1st. *A total absence of faculæ or faculous matter.* 2nd. *Absence of the usually observed scars, pores, and similar appearances.* 3rd. *An equal brightness of the whole surface, the limb being as luminous as the centre.*

Hofrath Schwabe desired us to go over his observations, which are at present at Kew Observatory, to extract similar facts formerly noticed, and to inform him whether some of these phenomena had also been observed in this country.

The observations were carefully scanned; and it was noticed that the phenomena occur only in years of minimum spot-frequency. The extracts, which we append, and which might have been multiplied, are quite sufficient to show the regularity of their recurrence, and also that the year 1833 was particularly characterized by the frequency of observations of them.

We also applied to the Rev. F. Howlett, whose well-known exquisite delineations of Sun-spots and faculæ gave us the best promise of learning something more relating to delicate changes on the surface of the Sun; but unfortunately Mr. Howlett's impaired health has obliged him to withdraw almost wholly from his usual application to Sun observations during the period in question. He however states in his answer, that "he had certainly noticed how uniformly bright the Sun's surface has been of late, in connection with an almost total absence of faculæ."

We think it right to state (without expressing our own opinion in the matter) that Hofrath Schwabe thinks he has noticed a connexion between Sun-spots and meteoric showers. He says in his last letter, "The minimum of spot-frequency coincides remarkably with the recurrence of meteoric showers, the period of rotation of which, viz., 33·2 years, agrees with a larger period of the sun-spots. In 1833 there was an extreme scarcity of spots (only 33 very small groups being observed),

and in 1866–67, after 33 years the phenomenon repeats itself. From the 1st January until to-day, June 8th, I have only observed 6 small groups, and out of 133 days of observation, there were 100 without spots. In the year 1848, which is the middle of the 33·2 years period, there was a maximum of spots. If the 33 years' period should be established by future observations, then a maximum of meteoric showers would always occur after three years of the usual Sun-spot periods. Whether this periodicity existed before, I cannot decide, but there appears to have been a minimum of Sun-spots in 1798·5, and a maximum in 1816·8."

We are at present engaged in determining a curve of spot-frequency during the last forty years, founded, not on the ***number of observed groups***, but on the ***area of spotted surface***, as observed by Hofrath Schwabe; and we hope that by this means the periodicity will be represented with greater precision than before, and also that more light will be then thrown on the whole subject; but in the meantime we would call the attention of all observers to the fact, that in the present state of our inquiries into the physical nature of the Sun and into the connexion of cosmical phenomena, even the most delicate changes observed deserve great attention, and that nothing should be overlooked by those who take an active interest in this problem.

June 14, 1867.

Extracts from Hofrath Schwabe's own Observations.

1833.	
February 6, 7	Surface of the Sun extremely uniform, and hardly any trace of faculæ and scars.
March 5	No faculæ. Sun spotless and without any scars.
April 6	A few indistinct scars. No pores observable.
,, 7	Sun spotless. Scars extremely minute. No pores.
,, 22	Surface very uniform; five scars, no faculæ and pores.
,, 23	Surface quite uniform, without faculæ. Similar observations until May 4th.
May 12, 13	Sun spotless, very uniformly bright and faculous matter very minute.
,, 14, 15	Sky not quite clear; Sun spotless, no faculæ or pores to be seen.
,, 20, 24, 25, 30 ..	Surface very uniform, with minute scars. No faculous clouds.
June 7, 8, 11	Spotless, very uniform, without faculæ. Towards the end of the month the scars more distinct and a few faculæ visible.
July 8, 16, 18, 29 ..	Spotless, surface very uniformly bright. Similar remarks during August, September, October, December, and during the beginning of 1834.

1844.	
February 9	The surface of the Sun appears very uniform, without considerable faculæ.
„ 12	Perfectly spotless; no faculæ near the limbs, nor scars in the centre. Throughout February no faculæ.
March 6, 30, 31	Spotless, very uniform, finely porous with a few minute scars.
April 2, 3, 5	A few cumuli of faculous matter, but no spots, points or pores.
May 12	No spots or faculæ. Similar observations until the end of September.
1855.	
February 23	Sun spotless; no faculæ, although many pores and fine points are observable.
June, July, and August ..	Sun spotless, surface extremely distinct, no faculæ, but innumerable pores and minute dots.

Note on the Spectrum of Comet II. 1867. By William Huggins, Esq., F.R.S.

Observations of this Comet were made on May 4th and 8th. In the telescope the comet appeared to consist of a slightly oval coma surrounding a minute and not very bright nucleus. This bright point was not central, but nearer to the *following* edge of the coma.

When the spectroscope was applied to the telescope, a continuous spectrum was formed by the light of the coma. I was unable, on account of the faintness of the nucleus, to distinguish with certainty the spectrum of its light from the broad spectrum of the coma on which it appeared projected. Once or twice I suspected the presence of two or three bright lines, but of this observation I was not certain.

The prismatic observation of this faint object, though imperfect, appears to show that this small comet is probably similar in physical structure to Comet I, 1866.*

Since some recent researches appear to suggest the existence of a possible connexion between some objects which have the appearance of comets and the phenomenon of periodical meteors, additional interest and importance are given to any observations which may help us to a better knowledge of these mysterious bodies.

* See *Proceedings Royal Society*, Vol. xv. p. 5.

Note on the importance of the Spectroscopical Examination of the Vicinity of the Sun when totally eclipsed, for the determination of the nature and extent of its Luminous Atmosphere, and on the partial identity of that Atmosphere with the Zodiacal Light. By Professor E. W. Brayley, F.R.S., F R.A.S.

Many facts conspire to prove that a faintly luminous atmosphere of great, but variable extent, encompasses the Sun exterior to the photosphere. Sir John F.W. Herschel has shown from the deficiency of light at the borders of the Sun's visible disk, that its extent must be considerable, not merely in absolute measure, but as an aliquot part of the Sun's radius. The phenomena of the luminous prominences evince the truth of this inference, Mr. De La Rue having found that the height of the summit of one of these clouds from the edge of the disk is about 72,000 miles, which is a little less than $\frac{1}{6}$ of the Sun's radius. But the phenomena of the Corona, and especially those of the projections from it, seen so remarkably at the total eclipse of the year 1860, tend to prove that a much greater extent than this, an extent equal to many radii of the Sun, must be attributed to the solar atmosphere.

The luminosity of the clouds (which, as Mr. De La Rue has also shown, have great photographic power) evinces that they consist of incandescent globules in the liquid state, or solid particles, probably of the metals discovered in the Sun by Kirchhoff. This implies the incandescence of the atmosphere itself in which they are suspended; but as they must be composed of gaseous matter, its light is necessarily very faint, and in fact is not yet known to have been observed.

The excessively elevated temperature which we must ascribe to space immediately around the Sun, and which, according to Professors Sir William Thomson and Mr. Tait, would convert a planet into vapour if within a few hundred thousand miles of the luminary, would imply that the extent of the atmosphere is limited only by the balance between its heat and its gravity, the former of which, from all solar phenomena, appears in a high degree to exceed the latter.

And this atmosphere, even to such an extent, must be incandescent (except, perhaps, at its exterior regions), but being gaseous, its luminosity will not be proportionate to its temperature in the same ratio as would exist in the case of a solid or a liquid, and as is manifested in the intense light of the photosphere, but as just noticed must be very faint.

This, doubtless, is the reason why under all ordinary circumstances it is invisible, being overpowered by the photospheric radiation or sunshine. It is this very faintness of its luminosity, which permits the deficiency of the light of the photosphere at the borders of the Sun's disk, occasioned by the absorptive action of the atmosphere, to be observed.

These considerations will evince the importance of the spectroscopical examination of the vicinity of the Sun when totally eclipsed, for the determination of the nature and extent of its luminous atmosphere. The researches of Kirchhoff have demonstrated, by a combination of optical and chemical evidence, that an absorptive gaseous medium surrounds the incandescent body of the Sun. It is perfectly consistent with that evidence to believe that the surface of the photosphere on which the spots burst forth, or to which their formative torrents rise, is the immediate source of the light, certain rays of which are absorbed by that medium, and so give the Frauenhofer lines. These, agreeably to the same researches, explain the chemical nature of the absorptive medium. But the gaseous, monochromatic, or bright-line spectrum, which, agreeably to our present knowledge, it must be inferred the exterior luminous atmosphere would give, is not witnessed, because it is overpowered by the continuous or ordinary solar spectrum. When, however, the photospheric radiation causing that spectrum is excluded by the eclipse, the vicinity of the Sun may be expected to yield a monochromatic spectrum, the situation of the bright lines in which will evince of what elements the exterior luminous atmosphere is composed. For reasons which I shall eventually submit to Astronomers and Spectroscopists, I venture to predict that when a suitable opportunity for the observation shall present itself, it will be found that the spectrum obtained will correspond to the spectra given by the unresolved Nebulæ, from which our Secretary, Mr. Huggins, has inferred that they do not consist of stars, but are masses of luminous gas. To this subject I shall return in the sequel.

It is most probable that the Sun's luminous atmosphere is conterminous, or rather identical in part, with the Zodiacal Light, which must thus be regarded as consisting of incandescent aeriform matter, through which take their course more luminous solid or solidifying particles — condensing bubbles of solar froth — which I have termed meteoritic masses, the particles of Cassini, and the meteors or meteoric masses of Olmsted, Biot, and Sir John Herschel.

If my views of the production of meteoritic masses by the condensation of solar aeriform matter be well founded, those of Sir John Herschel, of the planetary molecular constitution of the Zodiacal Light, will necessarily follow; but this is not incompatible with the co-existence of a gaseous solar atmosphere in which they are produced, and in and with which they continue to move. I shall hereafter endeavour to prove that the existence of a solar atmosphere of the extent and ellipticity of the Zodiacal Light is perfectly consistent with dynamical laws; the equilibrium of the solar atmosphere being however of a nature altogether different from that of the Earth's, or of any planetary atmosphere.

Of the visible structure of the Zodiacal Light, we have few

telescopic observations. It would seem that the telescope has scarcely been applied to it since the time of the elder Cassini. The Spectroscope has not been applied to it at all. But if these views are correct, when it shall be spectroscopically examined under favourable circumstances, (which cannot perhaps, be expected to occur in these climates, always seen in part as it must be through the least transparent strata of our atmosphere) the Zodiacal Light should yield a monochromatic spectrum, with bright lines making known the chemical composition of its gaseous portion. Some of the meteoritic masses which traverse it may very probably be themselves in a denser gaseous state, like the nucleus of a Comet, others will have become liquid or solid, and the collective glare of all these particles may be expected to give a faint continuous spectrum in addition.

It would be disingenuous in me, on account of several remarks which I have offered in the course of this Note, were I now to omit the announcement of my having arrived at the conclusion, that in all probability the bright-line or monochromatic spectra, from which Mr. Huggins has inferred the gaseous constitution of certain Nebulæ, are due in reality to the luminous atmospheres of their constituent Stars or Suns. I am about to submit to the Royal Society a paper in which the grounds of that conclusion will be stated.

London Institution, June 14th, 1867.

On the connexion between Comets and Meteors.

By G. Johnstone Stoney, M.A., F.R.S.

The astonishing fact which Sig. Schiaparelli brought to light some months ago, that there are comets moving in the tracks of the August and November meteors, compels us to infer that there is some intimate physical connexion between the two. In January last, M. Leverrier pointed out that such stream of meteors must have been in compact clusters when they underwent the great perturbations which brought them into permanent connexion with the Solar System. And Mr. Graham has lately shown that the meteoric iron which reaches our Earth had been at some previous time red-hot; and that when last red-hot it was acted on by hydrogen under considerable pressure—a pressure of perhaps six or more atmospheres. It is my present design to make use of these inferences as data,

and to endeavour to trace by their help, what the physical connexion between the comets and the meteors has been.

If interstellar space, external to the Solar System, be, as is most probable, peopled with innumerable meteoric bodies independent of one another, a comet while outside the Solar System would in the lapse of ages collect a vast cluster of such meteorites within itself. Each meteorite which approached the comet would in general do so in a parabolic orbit; and, if it came near enough to pass through a part of the comet, this parabolic orbit would by the resistance of the matter of the comet be converted into an ellipse. The meteor would therefore return again and again, and on each occasion that it passed through the comet its orbit would be still further shortened, until at length it would fall in, and add one to whatever cluster had been brought together by the previous repetitions of this process.* In this way, a comet while moving in outer space, beyond the reach of the many powerful disturbing influences which prevail within the Solar System, would inevitably accumulate within itself just such a globular cluster of meteorites as the November meteors must have been before they became associated with the Solar System.

When this body of meteors, enveloped by their comet, swept past the planet *Uranus* in the year 126, they may have come so close, that the comet brushed against the atmosphere of the planet. If this took place the comet must have both received a motion of rotation and been retarded.† The meteorites at its centre, retaining their speed, would accordingly gradually pass out through it and leave it a little behind; and when all got so far from the planet as to be beyond its further influence, the comet would be found moving round the Sun with a shorter periodic time than the meteors. This is in conformity with Dr. Oppolzer's determination of the periodic

* The behaviour described in the text is a consequence of the familiar formula for elliptic motion

$$V^2 = \frac{2\mu}{r} - \frac{\mu}{a},$$

since if at any distance r a resistance be experienced, V is thereby diminished, and as the formula must still hold good, a is also shortened.

† The cluster appears to have approached the orbit of *Uranus* from the outside, and, after passing the planet, to have described a relative orbit directed a little inwards towards the Sun, but principally backwards, *i.e.* in a direction the reverse of the planet's motion, with a relative velocity greater than the velocity of the planet. It in this way acquired a slow absolute motion, which was directed both inwards and backwards, and was thus started in its retrograde orbit round the Sun. A slight brush of the comet against the planet would both somewhat increase the curvature of the relative orbit, and slacken the comet's pace along it; and either of these effects would, under the circumstances which have been described, result in such a diminished absolute velocity as is attributed to the comet in the text.

time of the comet, viz. 33·18 years, that of the meteors being 33·25.*

The discovery of the Master of the Mint becomes now of exceeding interest, since it seems to show, first, that hydrogen is one of the constituents of comets; secondly, that the meteoric bodies he examined, when they originally joined their comet, fell in with a velocity sufficient to raise them, by the friction they suffered, to a red heat; thirdly, that the density of the comet was sufficient to occasion, in front of the advancing meteorite, a pressure of several atmospheres; fourthly, that when the meteors and the comet afterwards parted company, they glided asunder so quietly that the meteors were not again raised to any very high temperature; and, finally, that the friction they again encountered in passing through the Earth's atmosphere, was not sufficiently protracted to raise their internal parts to a red heat.

When the cluster of November meteors passed the planet which diverted them into the Solar System, they were unequally acted on by it, the path of those which lay nearest being most bent. To this, as M. Leverrier has remarked, is to be referred their subsequently moving in slightly differing orbits, with slightly different periodic times round the Sun, which after the lapse of many revolutions has gradually extended them along their nearly common path, and will as time goes on still further lengthen out the stream. Hence the feeble gravity of the comet was not sufficient to restrain the meteors which were originally within it from yielding to these weak forces. The gravity of the comet accordingly cannot have been what kept the parts of its own mass from giving way to the same influences, and being (like the meteors) drawn out into a long thread. This is one of several considerations,† which

* It should be remarked, however, that the comet seems to have fallen nearly a revolution behind the meteors since A.D. 126, *i.e.* in 52½ revolutions. If this be so, its periodic time must be less than Dr. Oppolzer's estimate, and is probably about 32·63 years; unless we may suppose that since its introduction into the Solar System, it has suffered a perturbation which has diminished its mean motion round the Sun. Such a perturbation is not impossible—it would arise, for instance, if a swifter stream of meteors overtook the comet and passed through it; and it is easy to assure one's self that a swarm of meteors having the requisite direction and speed to behave thus, may have been drawn into the Solar System by any one of the planets *Jupiter*, *Saturn*, *Uranus*, or *Neptune*.

It is not without interest to observe that whether the periodic time of the comet be 33·18 years or less, it will, before its next perihelion passage, have been run into by the meteors. The effect of this would seem to be first to accelerate the comet at the expense of some of the *vis-viva* of the meteors which pass through it; and finally, when the motion of the comet has been brought sufficiently into accordance with that of the meteors, to cause a gradual accumulation at the centre of the comet of those meteors which then happen to lie within the space occupied by it.

† Other grounds for this belief will be found in a Memoir on the Physical Constitution of the Sun and Stars, lately submitted to the Royal Society.

all point to the same conclusion—that a comet does not consist of matter merely held together by the mutual gravity of its various parts, but also coheres in virtue of some more powerful forces, perhaps not unlike those molecular forces which keep together the parts of a solid body.

It is remarkable that the principal meteoric streams which at the present day cross the Earth's path have a retrograde movement, although the motion of most of the comets that are known to be periodic is direct. Perhaps this is to be accounted for by the Earth's having exercised a more intense scattering influence upon whatever streams of meteors may have overtaken it, than upon those which came in the opposite direction. The Earth exerts an attraction which is competent to turn aside a meteorite of the former class through an angle of 50°, and to alter entirely its periodic time; but is too feeble to impress more than a trifling change in either the direction or period of bodies rushing past it with the speed of meteors moving in retrograde orbits.* Those chance meteors therefore which the

* The extreme cases will arise when a meteor passes the Earth, either in precisely the same direction as the Earth is moving, or in the opposite direction. In the former case it will approach the Earth (assuming that the meteor moves in some large orbit, which is necessary, since it is only the great planets of the Solar System, *Jupiter*, *Saturn*, *Uranus*, and *Neptune*, which can bring a swarm of meteors permanently in), with a relative velocity of about 0·4; in the latter case with a relative velocity of about 2·4 times the velocity of the Earth in its orbit. Hence the relative orbit which the meteor will describe under the influence of the attraction of the Earth will be hyperbolic; and the amount of deflection may be found as follows:—

From the equation of hyperbolic motion

$$V^2 = \frac{2\mu m}{} + \frac{\mu m}{a}$$

it follows that

$$a = \frac{\mu m}{V^2},$$

where a is the semiaxis major of the hyperbola, μ the coefficient of attraction, m the mass of the earth, and V the velocity of the meteor at a sufficient distance from the Earth to render $\frac{1}{r}$ negligible.

In the case of retrograde meteors

$$V = 2{\cdot}4,$$

taking the velocity of the Earth in its orbit as the unit of velocity. Again using the radius of the Earth + the height of the Earth's atmosphere as our unit of length, the distance of the Sun is about 22400. Hence from the equation $V^2 = \frac{\mu M}{r}$ for the Earth's motion round the Sun, we find

$$\mu = \frac{22400}{M},$$

and again $\frac{M}{m}$ (the ratio of the Sun's to the Earth's mass) is about 324000.

disturbing influence of the Earth or other small planet has occasioned, are probably, for the most part, the *débris* of streams which at one time were moving with a *direct* motion round the Sun.

Since we have now abundant reason to believe that the great circular stratum within which the members of the Solar System lie, is traversed in all directions by numbers of these meteoric bodies, so vast that, as Professor Newton has computed, $7\frac{1}{2}$ millions large enough to be visible to the naked eye on a clear night, and 40 times that number of smaller ones, enter the the Earth's atmosphere daily, we are no longer called on to assume the existence of a resisting medium, or of a departure from the law of gravitation, to account for the retardation of comets. Meteors passing through a comet indifferently in all directions, and with the same absolute speed, would operate upon it like a resisting medium.

Introducing these numbers we find that

$$a = \frac{22400}{324000} \cdot \frac{1}{(2{\cdot}4)^2} = \frac{1}{83}.$$

Now the deflection of a meteor's path in its relative orbit $= 2 \operatorname{cosec}^{-1} \frac{c}{a}$, and will of course be greatest when the meteor almost grazes the Earth's atmosphere, *i.e.* when $c - a = 1$.

Therefore the maximum deflection $= 2 \operatorname{cosec}^{-1} 84 = 1^\circ 22'$. This is the deflection as seen from the Earth, and corresponds to an absolute deflection in space of $2^\circ 20'$.

On the other hand, in the case of a meteor overtaking and passing the Earth,

$$a = \frac{22400}{324000} \cdot \frac{1}{(0{\cdot}4)^2} = \frac{1}{2{\cdot}314},$$

therefore the maximum deflection as seen from the Earth

$$= 2 \operatorname{cosec}^{-1} 3{\cdot}314 = 35^\circ,$$

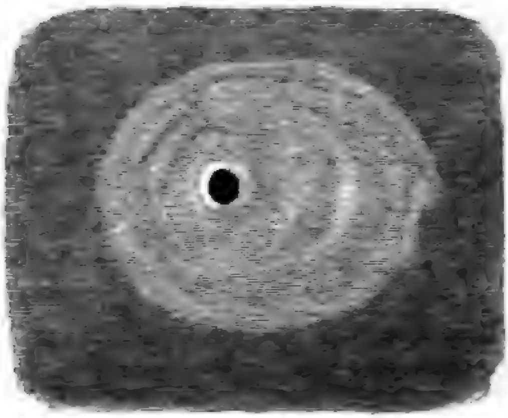
which corresponds to an an absolute deflection of 50°.

The difference between these deflections far more than compensates for the circumstance that the Earth would come across, and therefore have an opportunity of deflecting, about six times as many members of a retrograde swarm of meteors, as of a similar one travelling in a direct orbit.

Note on the Lunar Crater Linné.
By William Huggins, Esq., F.R.S.

The diagram which accompanies this note represents the Crater *Linné* as it appeared in the telescope on May 11th, 1867. The unusual steadiness of the atmosphere permitted the small Crater upon *Linné* to be seen with great distinctness.

May 11th, 1867.

W  E

8h. 45m.

Linné on this occasion presented the appearance of an oval white patch on the darker background of the *Mare Serenitatis*. The character of the surface of the white spot may be described as similar in appearance to that of a cloud, for it presented no distinct details, and remained undefined when the small neighbouring craters were seen with great clearness. The absence of any defined points upon which the eye can rest is probably the reason that the "boiling" motion of our atmosphere is perceived in a much more marked manner over the white spot, than on the adjoining sharply defined parts of the Moon's surface. From this cause *Linné* appeared, on several occasions, as a mass of white cloud in motion, at the same time that the craters near it were seen steadily and with distinctness.. This cloudy appearance arises probably from a peculiar, partly reflective property of the material of which *Linné* consists. Some other portions of the Moon's surface reflect light in an analogous manner.

At the time when the diagram was made, the shallow, saucer-like form of *Linné* was not seen, but I have detected it on other occasions. On the evening of July 8, at 7^h, when

a great part of the light reflected from our atmosphere was removed by means of a Nicol's prism placed next to the eye, I observed a shadow within the western margin of the shallow crater.

In the centre nearly of *Linné*, but rather nearer to the western margin, was seen the small Crater, as it is represented in the diagram.* This object was well defined in the telescope. The interior of the small Crater was in shadow, with the exception of a small part of it towards the east. The margin of the small Crater was much brighter on the western side, and at this part appears to be more elevated above the surface of *Linné*. Under very oblique illumination this high western wall appears as a small brilliant eminence, and casts a shadow which is somewhat pointed. In consequence of the presence of visitors in my observatory, I did not take measures of the small Crater. I estimated its diameter to be rather greater than one-fourth of the diameter of the white spot.

On the evening of July 9, at 9^h, the following measures were taken of *Linné*, and of the small interior crater. Under a power of 500 diameters, with which the measures were made, the boundary of *Linné* does not end abruptly, but passes gradually into the darker surface of the *Mare Serenitatis*. The white spot is oblong, but is not a regularly formed oval. At some parts of its outline small projecting portions of the bright surface interrupt the regularity of its figure.

The small crater, which appears to be deep, has a narrow margin, brighter than the white spot on which it occurs. The measures of this crater include the narrow, bright margin.

Length of the bright spot	7″·85
Breadth	6·14
Diameter of the small centre ..	1·71

1866, Dec. 14th. I observed the Moon with a Savart's polariscope attached to the telescope. The coloured bands passed unbroken across *Linné*, which appeared at the time as a white spot. Also when a double-image prism and plate of quartz were used, *Linné* was coloured similarly to the adjoining parts. The light from *Linné* contained a smaller amount of polarized light.

1867, Feb. 14th. I examined carefully the spectrum of the light reflected from *Linné*. The small size of the object makes this observation somewhat uncertain. The lines of Fraunhofer were seen with great distinctness in the spectrum of the Moon's light; but I failed to detect any lines which do not belong to solar light, in the narrow, brighter spectrum which was formed by the light from *Linné*.

Herr Schmidt is of opinion that a great change has recently taken place in the appearance of *Linné*, when it is viewed

* In the woodcut, the crater is a little too small in proportion to the white spot.

under oblique illumination. This conclusion is based upon a comparison of its present appearance with the descriptions of Lohrmann and Mädler, and with Herr Schmidt's own observations from 1841 to 1843.*

On this account it is of importance to note that the earlier observations by Schröter seem to agree very closely with the appearance which *Linné* now presents.

In Plate IX. of Schröter's *Selenotopographische Fragmente* the place occupied by *Linné* is marked by a round white spot, and not by the figure of a Crater. This white spot is a little smaller than the figure of the Crater *Sulpicius Gallus*. The spot is distinguished on the Plate by the letter *v*.

At page 181, Schröter gives the following description of this object: "Die sechste Bergader kommt von einer fast dicht an den südlichen Gränzgebirgen befindlichen, verhältlich gezeichneten Einsenkung *u*, streicht nördlich nach *v*, *woselbst sie wieder eine ohngefähr gleich grosse, aber ganz flache, als ein weisses, sehr kleines rundes Fleckgen erscheinende, etwas ungewisse Einsenkung in sich hat* . . . . "

I have put in Italics the words which apply to *Linné*. The observation was made, 1788, Nov. 5th, from $4^h\ 30^m$ to 8^h. The mean time of the observations was 7 days 14 hours after new Moon. Schröter employed a power of 161 on his 7-foot reflector.†

The description of this object as "a flat, somewhat doubtful Crater, which appears as a round white spot," agrees remarkably with the appearance which *Linné* now presents under similar conditions of illumination. The absence of any mention by Schröter of the small interior Crater, cannot be regarded as evidence of much weight, that this little Crater has been subsequently formed. An object so small might easily have been overlooked by Schröter. However, Lohrmann's description, in 1823,‡ and that of Mädler in 1831, do not appear to be in accordance with Schröter's observations, or with the present condition of the object.§ The observations were made with a refractor of 8 inches aperture, and with various powers from 200 diameters to 800 diameters.

* *Monthly Notices*, vol. xxvii. p. 93. *Ast. Nachrichten*, No. 1631. *Sitzungsberichte der K. Akademie, Wien*, Bd. lv., Feb. 1867.

† For his *measures* of the *Mare Serenitatis*, Schröter employed a reduced power of 95 diameters. In his second volume, at page 276, he gives an account of a re-examination of this part of the Moon's surface with more powerful telescopes. On this occasion (see Tab. LXIX.) *Linné* was not observed, probably because it was too close to the terminator. Schröter remarks, " . . . indem noch nicht einmahl die ganze Fläche erleuchtet war, sondern die Lichtgränze östlich durch sie vor den östlichen Gränzgebirgen weg lag."

‡ " A is the second Crater upon this plain—has a diameter which exceeds somewhat 1 mile, is very deep, and can be seen under every illumination." *Topographie der Mondoberflache*, p. 92, and Plate, Section IV.

§ A series of careful observations has been made by Prof. Respighi, *Les Mondes*, 13 Juin, 1867. See also observations of M. Flammarion, *Comptes Rendus*, Mai 20, 1867, and of M. Wolf, *Comptes Rendus*, Juin 17, 1867.

On the November Meteors. By W. Masters, Professor at Kishnaghur College, Bengal.

(*Addition to the Letter of 21st November*, p. 202.)

As a sequel to my letter regarding the November meteors, I beg to forward the following particulars.

The 27th to the 29th Nov., and 7th to 12th Dec. are dates for observing meteors of a similar kind.

Diverging meteors were not seen or detected again till half-past 2 A.M. of the 12th Dec.; they might have come on at an earlier hour; and they appeared to have passed off by 3 A.M.

They shot divergingly and with great rapidity, not from a point near δ *Leonis* or ι *Leonis*, but some point to the westward of these, between κ in the muzzle of *Leo Major* and the stars in the foot of the *Lynx* and the tip of its tail: some point about 29° or 30° of North Declination and 136° of Right Ascension. They darted out at the rate of about three per minute, were small, described short and thin arcs of light, and left no traces; hence it was difficult to fix with any degree of precision upon the exact point of divergence. Some showed themselves only as moderate blazes of light about 40° or 50° from this point, without any visible arc of light or course. A bright meteor with a long train shot across the area of divergence from nearly due south to north, or from *Alphard* in *Hydra* to ϑ in *Ursa Major*. This display of meteors had nothing brilliant or exciting in it; but notwithstanding its tameness I think it should be recorded.

Dec. 26, 1866. *Kishnaghur.*

Determination of the Longitude of the Sydney Observatory from Observations of the Moon and Moon-culminating Stars, made in the years 1859–1860. By E. J. Stone, Esq.

The late Director of the Sydney Observatory, Mr. Scott, has published two Volumes of Observations for the years 1859 and 1860. I find in these volumes forty-nine observations of the Moon at Sydney within less than 40m. variation in R.A. of a corresponding observation at Greenwich, each observation of the Moon being accompanied with at least one moon-culminating star common to both Sydney and Greenwich. I have compared these corresponding observations. The common stars only were used for the determination of clock error. The tabular

R.A. of the Moon for the Sydney observations has been interpolated from the time of observation. A slight correction has consequently been applied to the tabular R.A. of the Moon for Greenwich transit, as extracted from the *Nautical Almanac*, to obtain the result which would have been obtained by direct interpolation for the time of observation. The errors of Burckhardt's Tables in 1859 and 1860 are generally sufficiently large to render this correction necessary.

The longitude has been separately determined from observations of the two limbs of the Moon. The mean of these separate results has been adopted as the final result.

Attention has been confined to those nights on which one common culminator, at least, has been observed both at Sydney and Greenwich. All errors depending on assumed tabular places are thus eliminated, and as it is an invariable rule to observe the culminators with the Moon at Greenwich, only a few observations picked up in general under unfavourable circumstances are thus rejected. No observation has been rejected from mere discordance of result.

1859.

Date.	Number of Stars of Comparison.	Resulting Longitudes. ☽ 1 limb.	☽ 2 limb.
June 8, 9	1	10 4 51·49	
9, 10	1	45·26	
15	2	...	54·46
July 9	1	48·32	
11	2	50·00	
12, 13	4	41·15	
17, 18	2	...	48·99
21, 22	1	...	52·41
Aug. 12	1	43·29	
19	1	...	43·33
22	1	...	46·07
Sept. 6, 7	2	44·01	
9	2	48·42	
17	1	...	49·23
Oct. 4, 5	2	35·63	
6, 7	2	45·47	
8	1	44·39	
12	2	...	43·29
Nov. 3	2	45·96	
4	1	50·41	
Dec. 2, 3	1	43·08	
3	2	41·73	
8	2	45·83	
14	1	...	46·02

Weighting the results in accordance with the number of culminating stars observed, we have from observations of first limb,

$10^h\ 4^m\ 45^s{\cdot}05$. Weight 58.

From observations of second limb,

$10^h\ 4^m\ 48^s{\cdot}08$. Weight 27.

1860.

Date.	Number of Stars of Comparison.	Resulting Longitudes ☽ 1 limb.	☽ 2 limb.
Jan. 4	2	10 4 41·79	
9	1	...	45·26
Mar. 1	1	44·09	
5, 6	1	36·89	
Apr. 2	2	45·53	
4	2	48·16	
6	2	...	56·15
7	2	...	50·32
8	1	...	49·81
9	2	...	48·14
30	2	43·73	
May 1	1	44·99	
2	2	45·75	
3	1	48·06	
4	2	47·81	
June 30	1	53·13	
July 3	2	...	50·69
6	1	...	57·10
Aug. 6, 7,	2	...	48·13
27	2	48·89	
Oct. 5	2	...	45·36
Nov. 1	2	...	47·58
2	1	...	53·41
22	2	46·08	

Weighting the observations as before, we have from observations of the first limb,

$10^h\ 4^m\ 45^s{\cdot}81$. Weight 47.

From observations of the second limb,

$10^h\ 4^m\ 50^s{\cdot}05$. Weight 40.

Hence, combining the observations of the two years, we have for the resulting longitude,

h	m	s	
10	4	45·39	from observations of first limb.
10	4	49·26	from observations of second limb.

or, as the final result,

$$10^{h}\ 4^{m}\ 47^{s}{\cdot}32.$$

Approximate relative Dimensions of Seventy-one of the Asteroids. By E. J. Stone, Esq.

In the Supplement to the *Nautical Almanac* for the year 1868 will be found the mean opposition magnitudes of 71 of the asteroids. A considerable number of them have been determined by Mr. Pogson and may be considered entitled to great confidence. If we assume that the surfaces of the asteroids have equal reflective powers, we can, from these opposition magnitudes and the semi-axes major of the orbits, determine the relative dimensions of the mean reflecting surfaces of the asteroids. The relative diameters thus calculated are given in the following table. To turn the results into miles I have adopted diameters of *Ceres* and *Pallas* from the observations of Sir W. Herschel and Lamont.

Since the completion of these results I have found that the dimensions of the first 39 have been computed, from different data, by Dr. Bruhns, *De Planetis Minoribus.*

Name of Asteroid.	Diameter in Miles.	Name of Asteroid.	Diameter in Miles.
1. Ceres	196	16. Psyche	75
2. Pallas	171	17. Thetis	50
3. Juno	124	18. Melpomene ...	51
4. Vesta	214	19. Fortuna	56
5. Astrea	57	20. Massilia	65
6. Hebe	92	21. Lutetia	39
7. Iris	88	22. Calliope	78
8. Flora	61	23. Thalia	47
9. Melio	76	24. Themis	24
10. Hygeia	103	25. Phocea	36
11. Parthenope ...	63	26. Proserpine ...	44
12. Victoria	51	27. Euterpe	50
13. Egeria	60	28. Bellona	65
14. Irene	65	29. Amphitrite ...	83
[redacted]ia	92	30. Urania	44

Name of Asteroid.		Diameter in Miles.	Name of Asteroid.		Diameter in Miles.
31. Euphrosyne	...	46	52. Europa ...	...	72
32. Pomona ...	...	42	53. Calypso ...	...	29
33. Polyhymnia	...	36	54. Alexandra ...	...	40
34. Circe ...	...	29	55. Pandora ...	...	44
35. Leucothea ...	...	31	56. Melete ...	...	29
36. Atalanta ...	...	18	57. Mnemosyne	...	63
37. Fides ...	...	47	58. Concordia ...	...	31
38. Leda ...	...	40	59. Olympia ...	...	36
39. Lætitia ...	...	90	60. Echo ...	...	17
40. Harmonia ...	...	61	61. Danaë ...	...	38
41. Daphne ...	...	61	62. Erato ...	...	40
42. Isis ...	...	39	63. Ausonia ...	...	49
43. Ariadne ...	...	33	64. Angelina ...	...	44
44. Nysa ...	...	42	65. Maximiliana	...	63
45. Eugenia ...	...	44	66. Maia ...	...	18
46. Hestia ...	...	25	67. Asia ...	...	22
47. Aglaia ...	...	43	68. Leto ...	...	60
48. Doris ...	...	57	69. Hesperia ...	...	32
49. Palis ...	...	61	70. Panopia ...	...	36
50. Virginia ...	...	25	71. Niobe ...	...	46
51. Nemausa ...	...	38			

On the Lunar Crater Linné.

(*Extract from a Letter from Prof. Mädler to Mr. Birt.*)

"A few months ago I was honoured with a letter of yours, and now having looked over my original manuscripts respecting the Moon's surface, I take the liberty to answer.

"The Crater *Linné*, situated in $+ 27^\circ 47' 13''$ N.L. and $+ 11^\circ 32' 28''$ W.L. has a diameter of 1·4 geographical miles. In full moon, the edge of it is not very sharply limited, but in oblique illumination it is very distinct, and I have measured it seven times with great facility. The light of the edge is noted permanently 6°, the very small inner space has nearly or full the same brightness till the moment when shadows begin. I measured its co-ordinates, 1831 Dec. 12, five times, and Dec. 13, two times.

"*Bonn, June* 6, 1867."

Erratum in the Astronomer Royal's "Undulatory Theory. Macmillan and Co., 1866." By E. J. Stone, Esq.

On page 80 line 4, *for* "Let this angular diameter in seconds be *s*" *read* "Let this angular *semi-diameter* in seconds be *s*."

Mr. Knott's "calculated diameters of extreme disks," *Monthly Notices*, vol. xxvii, No. 5, page 191, require to be each multiplied by 2. It will then be seen that the observed diameters of the disks are *very* much smaller than the diameters of the first black rings, a result to be expected from the rapid degradation of the light as we proceed from the centre. See *Monthly Notices*, vol. xxvi, No. 2, page 45. The measures of disks must however from this cause be most uncertain.

Instrument for Sale.

A 30-inch Transit by Troughton and Simms; 2¾-inch object-glass; with micrometer eye-piece and all the modern improvements; cast-iron stand with adjustible bearings, and worm and tangent-screw at base.

Errata.

Page 223, "Additional Remarks on the Solar Eclipse of Nov. 6, 1867, by A. Brothers, Esq."

For Nov. 6, *read* March 6.

Page 229, line 10, *for* obscuration *read* observation.

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MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

Vol. XXVII. *Supplementary Notice.* No. 9.

Remarks on the Total Solar Eclipse of August 17th, 1868. By Dr. Edmund Weiss.

Though Major Tennant has a few months ago* already drawn the attention to the total solar eclipse of 17th August, 1868, I beg leave to do so once more, as I have extended the computations to the whole track of the shadow, and wish to add a few remarks, which, I suppose, will increase highly the interest in that eclipse.

I have computed the central line and the limits of the totality by the formulæ given in the excellent paper by Hansen on the Theory of Solar Eclipses,† because I have found them by far the most convenient for these calculations. The track of the shadow during the eclipse is the following:

NORTHERN LIMIT.

	Local Apparent Time h m	Longitude E. ° ′	Latitude N +, S − ° ′
August 17	17 46·2	35 6·2	+ 11 53·1
	18 0	38 31·6	12 41·3
	18 40	47 55·7	14 42·3
	19 20	56 36·5	16 12·7
	20 0	64 38·4	17 11·0

* *Monthly Notices*, vol. xxvii. p. 79 and 174.

† Hansen, *Theorie der Sonnenfinsternisse und verwandten Erscheinungen.* Leipzig, 1858.

the Earth, a minimum. The result of the coincidence of all these favourable conditions is an eclipse, which, as to its size, belongs to the largest that can happen in general, and has indeed in the annals of mankind no rival, since in the records of ancient eclipses there are to be found only two, which may be compared in size with that of August 17, 1868, but none in which the totality lasts so long. The first of these is the eclipse of Thales (28 May, 585 B.C.), which is said to have been the first predicted, and to have terminated a bloody war between the Lydians and the Medes. The second was visible on the 17 June, 1433, in Scotland, and the time of its occurrence was long remembered by the people of that country as "the black hour."

Besides its enormous size, the eclipse deserves in another respect special attention. In researches on the nature of the red prominences and other phenomena visible during total solar eclipses, it would certainly be of the highest importance to know something about the quality of the changes to which these appearances are subject. But, on a single place in the path of the shadow, the time of their visibility is too short to permit of the hope of perceiving in the meanwhile physical changes in them: this is, however, not quite improbable, if observations can be obtained on several places along the zone of the totality, which of course is only achievable when the shadow touches a series of accessible regions, affording the chance of fine weather. In the present eclipse this takes place in a very favourable manner. Soon after sunrise the totality commences on the Isle of Perim and in Aden; runs in the forenoon across India proper; reaches at noon Annam and Po. Condore; passes in the afternoon Borneo, Celebes, and many isles of the Molucca Archipelago, and finally becomes visible at New Guinea about sunset.

I think these remarks will suffice to show the importance which observations of this eclipse arranged systematically along the path of the shadow could attain, without mentioning peculiar questions, which, if at all, can be solved only by eclipses of this size. I also do not doubt, that persons enough could be found who would readily undergo the fatigues of the long journey and hot season, if the Indian Government could be induced to give aid for reaching several points in the eclipsed countries. At the instigation of Major Tennant, the Council doubtless have already taken pains to procure facilities for observers in India proper: I hope my remarks will cause the Council to ask for such also for the eastern, most important parts of the central line. At all events, a speedy publication of the accorded facilities is necessary, that this eclipse may not be lost only on account of the distance of the totally eclipsed regions, as probably centuries will pass before so favourable an occasion of extending our knowledge of solar physics will again occur.

Vienna, August 17, 1867.

A new Determination of the Diurnal Rotation of the Planet Mars. By Richard A. Proctor, Esq. B.A.

The determination of a Planet's period of rotation, to any great degree of exactness, may appear a waste of labour. Sir W. Herschel considered such problems worthy of attention, however, as supplying us with a time-measurer *external to the Earth*, and therefore possibly enabling us to detect slow changes in the Earth's rotation. The planet *Mars*, undisturbed by the attractions of a satellite (unless, indeed, some small Moon as yet undiscovered attends upon him), and marked by easily recognisable features, is clearly the one to be selected for such a purpose; and although modern astronomers would hardly look to *Mars* for information respecting such changes, yet, I think, the bare possibility that at some future date the rotation of *Mars* may serve this purpose will make the investigation of the subject interesting to astronomers.

Having by me a large number of pictures of *Mars*, and especially a series of charming tracings kindly given to me by Mr. Dawes, I determined to test the periods assigned by Mädler and Kaiser ($24^h\ 37^m\ 23^s{\cdot}8$ and $24^h\ 37^m\ 22^s{\cdot}6$ respectively). I found that, when the pictures taken by Mr. Dawes in 1852, 1856, 1860, 1862, and 1864, were examined in pairs, the period $24^h\ 37^m\ 23^s$ was perfectly satisfactory. Satisfied, therefore, that this period (or 88643 seconds) was undoubtedly very near the true one, I took the longer intervals. After being misled for a time by fig. 3, plate xvii. in Lardner and Dunkin's *Astronomy*, which seemed to represent the same phase as Dawes' picture of Oct. 3, 1862 (see Lockyer's also of the same date, in vol. xxxii. of our *Memoirs*), I noticed that, with the appended date and hour, that picture (so viewed) was irreconcileable with the picture of Sept. 14th, 1830. Selecting the latter picture as far more marked of the two, I arrived at the conclusion that the period of 88643 seconds was slightly too great. Kaiser's value, 88642·6, seemed, on the other hand, slightly too small. I proceeded to yet longer intervals with the provisional period 88642·8, which I was satisfied was very nearly correct. The remainder of the calculation I will give more at length. So far as I am aware the rotation of *Mars* has never before been tested by such long intervals.

I took, first, Herschel's observation of Sept. 30, 1783, for comparison with Dawes' observation of Oct. 3, 1862. There are several peculiarities about this selection. First, the planet was nearly at the same part of its path (it is noteworthy that 42 revolutions of *Mars* differ by less than a day from 79 revolutions of the Earth); secondly, he presented nearly the same face, and, thirdly, the dates of observation nearly coincide. It will be found that the interval actually separating the two observations (Herschel's made at $10^h\ 30^m$, Dawes at $12^h\ 15^m$) is

2493,251100 seconds.

(It will be remembered that 1800 was not a leap-year.) But there is a correction for phase, since the planet had not quite reached the phase seen by Herschel when Dawes observed it. There is also a slight correction for difference of geocentric longitude, about 4°. Both corrections are additive, and they amount together to about 4000 seconds. The resulting period

2493,255100 seconds,

divided by 88642·8, gives a quotient 28127 *very nearly*. This is the number of revolutions which had elapsed between the two observations. Dividing, therefore, 2493,255100 seconds by 28127, we get the period

88642·76 seconds.

To test this we can apply a much more extended interval. For in the *Phil. Transactions*, vol. i. 1666, there are two pictures taken by Hooke in 1666. They are dated March 3rd, 1665 (0^h 20^m and 0^h 30^m morning), which being translated into our present style becomes March 13th, 1666 (12^m 20^h and 12^m 30^h). These pictures, the only fairly recognisable ones in the set of pictures by Hooke and Cassini (shown in the same plate), represent that long sea running north and south with which Astronomers are familiar.

I found that opposition occurred, in 1666, a day or so after the vernal equinox, and therefore selected, first, a picture taken by Dawes, at 10^h 50^m, April 24th, 1856, in which year opposition occurred on April 2nd. The corrections for phase and geocentric longitude I estimated at -7385 seconds and $+2462$ seconds respectively; and it will be found that the period separating the two observations (taking the earliest of Hooke's) amounts (when thus corrected) to

5999,519276 seconds;

dividing this by 88642·76 seconds we get, *almost exactly*, 67682,—so nearly, indeed, that there is no necessity for the inverse operation.

I took, lastly, Hooke's first observation for comparison with that made by Dawes at 11^h 46^m, Nov. 26th, 1864, an interval of more than 198 years. In this case there was a difference of about 247° in geocentric longitude, and a difference of about 13° in phase, both tending to diminish the interval. These gave 64020 seconds to be subtracted from the interval of 6270,564360 seconds separating the dates of observation. The resulting interval

6270,500340 seconds,

divided by 88642·76 gives 70739 *very nearly*, and this there-

fore is the number of revolutions of *Mars* which had taken place in the interval. Dividing

6270,500340 seconds by 70739

we obtain the rotation period,

88642·762,

which may be assumed to be correct to the second decimal place, since three periods of 79, 190, and 198 years, respectively, agree in giving the same value. Thus we may assign as the true length of the Martial sidereal day,

$24^{h}\ 37^{m}\ 22^{s}\!\cdot\!76$

exceeding our own by

$41^{m}\ 18^{s}\!\cdot\!67.$

It is worthy of notice that there cannot possibly (owing to the method of calculation adopted) be an error of one complete revolution of *Mars* in the above period of 198 years. Also Hooke's picture is perfectly recognisable. The only cause of error to be considered is that arising from defective drawing. Assigning an error corresponding to half-an-hour's rotation to Hooke's picture, and an error half as large to Dawes' (he must forgive my assuming so large an error in his beautiful drawing, but I am taking an extreme case), we get a *possible* error of

$$\frac{1800+900}{70739} = \frac{1}{26}\text{th of a second,}$$

very nearly $=\cdot 04$ of a second approximately. But I believe the value obtained differs from the true value by a much smaller amount even than this.

Since the above was written I have gone through the calculations anew, and have detected an error (not in my own work, however) affecting the result by about one-seventieth part of a second.

I had used the synodical period 779·836, given in Nichol's *Cyclopædia of the Physical Sciences*, Mitchell's *Astronomy*, and other works. On testing this value I found it should have been 779·936, and in referring to Loomis' *Practical Astronomy* I find the elements correctly given. The mistake, by a singular accident, corresponds to that which would have arisen if the Earth's tropical period had been used (instead of the sidereal period) in determining *Mars'* mean synodical period. (I say a singular accident, because the mistake is certainly due to misprint only.) Thus the effect of the error is equivalent to the neglect of precession. Instead of *Mars* being in opposition at an epoch determined by the false value, the Earth was in advance of *Mars* by an arc of $50''\!\cdot\!1 \times t$, where t is the number

of years between the epoch and that later opposition from which the epoch had been calculated. For instance, instead of *Mars* being in opposition on about the 22nd of March, 1866, a date estimated from the opposition of April 2nd, 1856, the Earth was

$$50''\cdot 1 \times 190 = 9919'' = 2\tfrac{3}{4}^\circ \text{ (about)}$$

in advance of *Mars*. This affects the correction for geocentric longitude in the comparison between Hooke's observation and Dawes'. The planet being, on March 13th, 1666, nearly in opposition, and about $\frac{2}{3}$rds as far from the Earth as the Earth from the Sun, we obtain (roughly) a correction of

$$2\tfrac{3}{4}^\circ \times \frac{3}{2} = 4\tfrac{1}{8}^\circ \text{ about}$$

This correction is *subtractive*, and corresponds to rather more than $\frac{1}{90}$th of a Martial day, divided by the number of rotations in about 190 years, that is, to rather more than

$$\left(\frac{88642\cdot 3}{90} \div 67650 \text{ seconds}\right)$$

or as nearly as possible to 0·015 seconds, or diminishes the rotation-period to

$$24^h\ 37^m\ 22^s\cdot 745,$$

which we cannot consider accurate beyond the second decimal place. I believe the true value lies certainly between

$$24^h\ 37^m\ 22^s\cdot 74$$

and

$$24^h\ 37^m\ 22^s\cdot 75.$$

It will of course be obvious that, since the whole correction due to the error here detected is only one-seventieth of a second, it would have been useless to have calculated the correction more closely. Also the correction affects all the determinations by about the same amount.

Another effect of the correction is that, instead of 79 sidereal revolutions of the Earth and 42 of *Mars* differing by less than one day, as stated above, the true difference is 2·116 days.

On an Expression for the Angular Distance of two Planets. By A. Cayley, Esq.

If for the planet m, referred to any fixed plane and origin of longitudes, we have

v, the longitude in orbit
θ, the longitude of node
ϕ, the inclination

and similarly for the planet m' referred to the same fixed plane and origin of longitudes, if the corresponding quantities are v', θ', ϕ'; then the angular distance of the two planets will of course be expressible in terms of v, θ, ϕ, v', θ', ϕ', but I am not aware that the actual expression has been given. To obtain it in the most simple manner, I write further for the planet m:—

$\theta + x$, the reduced longitude,

y, the latitude,

z, the distance from node,

so that $z\ (= v - \theta)$, x, y, are the hypothenuse, base, and perpendicular of a right-angled spherical triangle, the base angle of which is $= \phi$. And similarly $\theta' + x'$, y', z', have the like significations for the planet m'. I write also r, r', for the distances of the two planets respectively.

This being so, the rectangular co-ordinates of the planet m are

$$\begin{aligned} &r \cos y \cos (\theta + x), \\ &r \cos y \sin (\theta + x), \\ &r \sin y, \end{aligned}$$

But observing that from the right-angled triangle we have

$$\begin{aligned} \cos z &= \cos x \cos y, \\ \cos \phi &= \tan x \cot z, \\ \sin x &= \cot \phi \tan y; \\ \sin y &= \sin \phi \sin z, \end{aligned}$$

and therefore also

$$\sin x \cos y = \cot \phi \sin y = \cos \phi \sin z,$$

the expressions for the co-ordinates become

$$\begin{aligned} &r (\cos z \cos \theta - \sin z \sin \theta \cos \phi), \\ &r (\cos z \sin \theta + \sin z \cos \theta \cos \phi), \\ &r (\qquad\qquad \sin z \sin \phi). \end{aligned}$$

Forming the analogous expressions for the co-ordinates of m', then if H be the angular distance of the two planets, we deduce at once the expression for cos H, viz. this is—

$$\begin{aligned} \text{Cos H} = {} & (\cos z \cos \theta - \sin z \sin \theta \cos \phi)\ (\cos z' \cos \theta' - \sin z' \sin \theta' \cos \phi') \\ & + (\cos z \sin \theta + \sin z \cos \theta \cos \phi)\ (\cos z' \sin \theta' + \sin z' \cos \theta \ \cos \phi') \\ & + (\qquad \sin z \sin \phi \qquad)\ (\qquad \sin z' \sin \phi' \qquad), \end{aligned}$$

or, multiplying out, this is

$$\begin{aligned}\operatorname{Cos} H = {} & \cos z \cos z' \cos(\theta-\theta') \\ & + \cos z \sin z' \sin(\theta-\theta') \cos\phi' \\ & - \sin z \cos z' \sin(\theta-\theta') \cos\phi \\ & + \sin z \sin z' (\cos(\theta-\theta') \cos\phi \cos\phi' + \sin\phi \sin\phi'),\end{aligned}$$

say this is

$$\begin{aligned} & = A \cos z \cos z' \\ & + B \cos z \sin z' \\ & + C \sin z \cos z' \\ & + D \sin z \sin z',\end{aligned}$$

viz. it is

$$\begin{aligned} & = \cos(z-z') \,.\quad \tfrac{1}{2}A + \tfrac{1}{2}D \\ & + \sin(z-z') \,.\; -\tfrac{1}{2}B + \tfrac{1}{2}C \\ & + \cos(z+z') \,.\quad \tfrac{1}{2}A - \tfrac{1}{2}D \\ & + \sin(z+z') \,.\quad \tfrac{1}{2}B + \tfrac{1}{2}C\end{aligned}$$

But we have

$$z - z' = v - v' - \theta + \theta',\; z + z' = v + v' - \theta - \theta',$$

whence the expression becomes

$$\begin{aligned}\operatorname{Cos} H = {} & \cos(v-v') \,.\left(\tfrac{1}{2}A + \tfrac{1}{2}D\right)\cos(\theta-\theta') - \left(-\tfrac{1}{2}B + \tfrac{1}{2}C\right)\sin(\theta-\theta') \\ & + \sin(v-v') \,.\left(\tfrac{1}{2}A + \tfrac{1}{2}D\right)\sin(\theta-\theta') + \left(-\tfrac{1}{2}B + \tfrac{1}{2}C\right)\cos(\theta-\theta') \\ & + \cos(v+v') \,.\left(\tfrac{1}{2}A - \tfrac{1}{2}D\right)\cos(\theta+\theta') - \left(\tfrac{1}{2}B + \tfrac{1}{2}C\right)\sin(\theta+\theta') \\ & + \sin(v+v') \,.\left(\tfrac{1}{2}A - \tfrac{1}{2}D\right)\sin(\theta+\theta') + \left(\tfrac{1}{2}B + \tfrac{1}{2}C\right)\cos(\theta+\theta'),\end{aligned}$$

or substituting for A, B, C, D, their values, and after a few easy reductions, we find

$$\operatorname{Cos} H = \cos(v-v')\left\{\begin{array}{ll}\tfrac{1}{2} + \tfrac{1}{2}\cos\phi\cos\phi' - \tfrac{1}{2}(1-\cos\phi)(1-\cos\phi') & \sin^2(\theta-\theta') \\ \qquad\qquad + \tfrac{1}{2}\sin\phi\sin\phi' & \cos(\theta-\theta')\end{array}\right\}$$

$$
\begin{aligned}
&+ \sin(v-v') \left\{ \frac{1}{2}(1-\cos\varphi)(1-\cos\varphi') \sin(\theta-\theta') \cos(\theta-\theta') \right. \\
&\qquad \left. + \frac{1}{2} \sin\varphi \sin\varphi' \qquad\qquad \sin(\theta-\theta') \right\} \\
&+ \cos(v+v') \left\{ \frac{1}{2}(1-\cos\varphi\cos\varphi') \cos(\theta-\theta') \cos(\theta+\theta') \right. \\
&\qquad + \frac{1}{2}(\cos\varphi-\cos\varphi') \quad \sin(\theta-\theta') \sin(\theta+\theta') \\
&\qquad \left. - \frac{1}{2} \sin\varphi \sin\varphi' \qquad\qquad \cos(\theta+\theta') \right\} \\
&+ \sin(v+v') \left\{ \frac{1}{2}(1-\cos\varphi\cos\varphi') \cos(\theta-\theta') \sin(\theta+\theta') \right. \\
&\qquad - \frac{1}{2}(\cos\varphi-\cos\varphi') \sin(\theta-\theta') \cos(\theta+\theta') \\
&\qquad \left. - \frac{1}{2} \sin\varphi \sin\varphi' \qquad\qquad \sin(\theta+\theta') \right\}.
\end{aligned}
$$

For $\varphi = \varphi' = 0$, the formula becomes, as of course it should do,

$$\text{Cos H} = \cos(v-v').$$

It may be added, that if f, f' are the true anomalies, ω, ω' the longitudes of pericentre in orbit, then $v=\omega+f$, $v'=\omega'+f'$; and we thence have for cos H, formulæ of the like form, containing $\cos f \cos f'$, $\cos f \sin f'$, $\sin f \cos f'$, $\sin f \sin f'$, or containing $\cos(f-f')$, $\sin(f-f')$, $\cos(f+f')$, $\sin(f+f')$ respectively, in place of the like functions of z, z', but with of course altered values of the co-efficients.

Note on Stars within the Trapezium of the Nebula in Orion. By David Gill, Jun., Esq.

On the 22nd February, 1867, at 10 p.m., G.M.T., I had been measuring the position and distances of two components of the multiple star θ *Orionis*. The definition being unusually fine, I extinguished the lamp to look at the Nebula.

I was immediately struck by a twinkling within the trapezium which, by careful watching, I was enabled to map down as two faint stars.

On receiving the *Astr. Register* for March 1867, I found that Mr. Huggins' diagram there given, corresponded with mine as to the stars 5 and 7. This diagram is copied from the *Monthly Notices* for January 1866.

My diagram also showed a star marked "suspected," similar in R.A. to No. 9, and of the Decl. of δ.

This star was so very, very faint I could only catch it by momentary glimpses, and can hardly depend on its position.

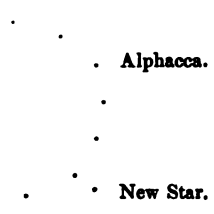
These three were the only stars seen by me. The instrument used was the excellent Equatoreal of the Observatory, King's College, Aberdeen, by A. Ross (formerly Mr. Burr's) of 3¾-in. aperture; power used, 195. I have every confidence in the observation, because my diagram was made without previous knowledge of the existence of No. 7.

The star could not have been formed by reflection from the eye-piece, as the clock motion was stopped, and the star allowed to transit across the field.

Aberdeen, 28th August, 1867.

On the New Variable T *Coronæ.* By M. Walter, Esq. Surgeon H.M. 4th Reg. North-India.
(*Extract of a Letter to Mr. Stone.*)

As you evidently take much interest in all matters connected with this *Stella Mirabilis*, I venture to address you, with some hesitation and diffidence, with a view to correct an error as to the time of its first appearance, which you state must have been between nine and midnight on the 12th of May last year. Now I am certain that this same conflagration was distinctly perceptible here at least six hours earlier. And my knowledge of the fact came about in this wise. The night of the 12th of May last year was exceedingly sultry, and about eight o'clock on that evening I got up from the tea-table and rushed into my garden to seek a cooler atmosphere. As my door opens towards the east, the first object that met my view was *Corona Borealis*, which had then an altitude of some 45 degrees. My attention was at once arrested by the sight of a strange star outside the *Crown*, which was then certainly quite as large and bright, I thought rather more so, as its neighbour *Alphacca*. I was so much struck with its appearance that I exclaimed to those indoors, "Why here is a new comet;" and so impressed was I with this idea of its being a comet that I immediately made the following rough diagram of its relative position with the rest of the stars in the *Crown*, that I might be able to trace any movement on a future night:—



Now as the longitude of this place is about 78°33′, our time

is $5\frac{1}{4}$ hours earlier than yours; and as I saw the star at 8 p.m. on the 12th, it must have been visible with you as soon as the shades of evening admitted of the stars being seen on that date, and therefore Dr. Schmidt must by some mischance have overlooked it at Athens.

I may observe that I mentioned the circumstance of a new comet being visible to some of my brother officers on the following morning, and asked them to come and see it in the evening, which they did.

Should you deem the circumstance of the phenomenon having been seen earlier than you supposed of any importance, I may mention that my good friend Captain Henry Toynbee, a Fellow of the R.A.S., and therefore easily accessible to you, is well acquainted with me, and will I have no doubt testify to my being acquainted with stellar observations, and that full confidence may be placed on my statements.

Secunderabad, Deccan, India,
May 12, 1867.

Occultation of o^2 Libræ, 1867, *May* 17.
By C. G. Talmage, Esq.

G.M.T. of Disappearance = 11 56 45·95.
,, Reappearance = 12 58 55·23.

Time of disappearance exact, Moon's limb remarkably steady; at the reappearance, star very faint.

Mr. Barclay's Observatory,
Leyton, Essex.

Observations of Comet II. 1867 (*Tempel's*).
By C. G. Talmage, Esq.

		G.M.T.	Diff. of R.A. Comet — ✱	Diff. of Decl. Comet — ✱	No. of Obs.
			s	′ ″	
1867, May	24	10 31 21·33	+ 13·44	+ 11 54·25	5
1st star	29	11 4 33·63	− 57·90	+ 7 59·21	5
2nd star	29	11 21 51·04	− 223·67	+ 0 56·82	3
	30	12 10 53·80	+ 119·00	+ 1 21·14	3
	31	10 59 46·79	+ 17·30	+ 7 23·60	5

I have not at present identified these stars; if any Astronomer has observed them on the meridian, I should be much obliged by his sending me the places.

		Comet R.A.	Comet Decl.	
	h m s	h m s	° ′ ″	
1867, June 1	10 32 23·60	15 4 2·86	−6 3 56·95	5
2	10 57 2·55	15 4 23·78	−6 29 8·40	3

June 1. Exceedingly faint, difficult observation; comparison star, W. B. *Hora* 14, No. 1155.

June 2. Steady night, observations fair; comparison star, W. B. *Hora* 14, No. 1085.

Mr. Barclay's Observatory,
Leyton, Essex.

Jupiter without his Satellites. By C. Leeson Prince.

Aug. 21st, 1867. In the early part of this evening, such heavy clouds were spread over the sky, from the zenith to the south-east horizon, that small hope could be entertained of seeing the interesting phenomenon of the planet *Jupiter* divested of his satellites. At 9^h 26^m L. M. T. I first saw the planet through a gap in the clouds after the disappearance of the second satellite, and before the appearance of the fourth satellite, upon *Jupiter's* disk. The atmosphere at this time was in such a state of tremor, that although I watched the fourth satellite coming up to the planet's limb, yet I could not even estimate the time of immersion. However, at 9^h 35^m, it was fairly upon the disk, and appeared as a round *black* spot, its colour being as nearly as possible that of its own shadow, and very nearly equal to that of the third. The shadow of the fourth was decidedly irregular, larger than the satellite itself, and I thought slightly elongated towards the north-west. The third satellite was of a dark grey colour, and certainly less dark, than I had often seen it. At 9^h 40^m the planet was obscured by clouds, and I could not see it again till 10^h 20^m, when the first satellite and its shadow had appeared upon the scene, and consequently *Jupiter* was completely shorn of his satellites. About this time I could discover scarcely a shade of difference between the colour of the fourth satellite and its shadow and that of the first and third; the shadow-spot of the third being perhaps a little darker. At eleven o'clock the definition very much improved, and I was able to take a sketch of the phenomenon with tolerable accuracy. The belts were very well defined, and at intervals the northern edge of the southern belt appeared beautifully lit up, much resembling in miniature the edge of a cumolo-stratus cloud, when the sun is shining upon it. There were also two conspicuous indentations along this edge of the belt. I obtained frequent glimpses of the first satellite during its transit, and it commenced shining much brighter than the

body of the planet 18 minutes before emersion; the third commenced shining as brightly as usual 14 minutes before emersion. Unfortunately a dense fog came on soon after 1 o'clock which prevented my seeing the emersion of the fourth.

In the *Monthly Notices* (vol. xx. p. 245) is an interesting letter from the Rev. W. R. Dawes, on the appearance of *Jupiter's* satellites while transiting the disk of the planet, in which he states, "That some of the satellites of *Jupiter*, while passing over the planet's disk appear as dark spots, is noticed by Sir John Herschel as having been *first* observed by Schröter and Harding; probably, therefore, some thirty or forty years ago; but it is not stated where their observations of the phenomenon were published." Upon the present occasion, therefore, I beg to call attention to the fact, that the phenomenon of the fourth satellite appearing as a dark spot upon the planet's disk was observed and recorded by Mr. J. Pound, 148 years ago. This observation may be found in vol. xxx. of the *Phil. Transactions*, or at p. 307 in the fourth vol. of their Abridgement by Henry Jones, M.A. As it is probable that many Fellows of the Society may not have ready access to these early vols. of the *Phil Trans.*, I have copied Mr. J. Pound's communication to the Royal Society. It was as follows:—

"On the 16th of February, 1719, at 6^h, through a short tube, we saw all the four satellites, the three outermost on the east side of *Jupiter*, and the innermost near the western limb, approaching to an eclipse. The fourth at that time was about half a semi-diameter of *Jupiter* from the eastern limb. Then it proved cloudy till about 8^h, at which time (through the Huygenian telescope) we could see only the second and third satellites, the first being behind *Jupiter* in the shadow, and the fourth entered upon the disk. We saw at this time a dark spot a little northward of the greater zone, and near the eastern limb, where the satellite was to enter upon the disk; which spot we took for the shade of the satellite. The clouds then again intercepted our view, till 8^h 53^m Æq. T., at which time the first satellite was lately emerged out of the shadow, and the spot advanced so far, that we perceived it would arrive at the middle of *Jupiter*, near two hours sooner than the shade ought to have done by our computation; but not imagining, that this dark spot could be any thing else but the shade, we concluded there had been some error in the calculation, which we thought to re-examine afterwards. On this presumption we left off observing till 9^h 35^m, at which time we were surprised to see a notch in the limb of *Jupiter*, near the place where the former spot entered. This last appearance agreeing well with the time that the shade of the satellite ought to have entered the disk, soon made us alter our former opinion, and conjecture, that this, and not the other spot, was

the said shade. At 9^h 39^m Æq. T., the notch vanishing, a round black spot appeared within the limb, but in contact with it. At 9^h 45^m we judged the first spot, and at 11^h 45^m the second, to be in the middle of *Jupiter*. At 11^h 50^m the first spot touched the limb, being within the disk; soon after which the limb in that place seemed a little protuberant. At 12^h 5^m appeared the fourth satellite just come out of the disk, and touching the limb in the place where the protuberancy was. At 12^h 7^m we could perceive the satellite separated from the limb. At 13^h 56^m the second black spot, still within the disk, just notched the western limb; soon after which there appeared a notch in this part of the limb, as it did on the other at the coming on of this spot. At 14^h 6^m the spot was all gone off, and the limb appeared clean and entire. The first spot, when in the middle of *Jupiter*, was almost as black as the second when near the limb, but somewhat less and a little more northerly. At the time that the first spot was in the middle of the disk, the three innermost satellites appeared to the east of *Jupiter;* the first (as aforesaid) having lately emerged out of the shadow; the second being almost at its greatest distance; and the third having passed the axis of the shade about twelve hours before, and apparently at this time about three diameters of *Jupiter* from his limb. The times that these spots arrived at the middle of the disk are agreeable to the times found by calculation, in which the fourth satellite and its shade ought to have appeared there. From all which it is very plain, that the first of these spots was *the fourth satellite itself*, and the second its shadow. We have seen the first and second satellites appearing not as dark spots, but as bright ones (somewhat different from the light of *Jupiter*), for some little time after they have entered his disk, but as they approached the middle we lost sight of them. And we have frequently observed, that the same satellites appear brighter at some times than others; and that when one of them hath shined with its utmost splendour, the light of another hath been considerably diminished. From whence it is very probable, at least, not only that the satellites revolve upon their proper axis, but also that some parts of their surfaces do very faintly (if at all) reflect the solar rays to us. All which hath for some time since been observed and taken notice of by Messrs. Cassini and Miraldi, as may be seen in the *Memoirs of the Académie Royale*, for the years 1707 and 1714."

Observatory, Uckfield,
Sept. 4th, 1867.

On the Eclipse and Transits of Jupiter's Satellites, 21st August, 1867. By C. H. Weston.

During the unusual phenomena which occurred on the evening of the 21st of August, some points of interest attracted my attention, which I beg to lay before our Society.

A bright eastern bank of clouds in the otherwise clear sky obscured the early observations of the satellites. But the night was fine and clear, and the definition of *Jupiter* exceedingly good.

On this occasion I used a 9-inch Newtonian reflector, with a non-inverting pancratic eye-piece.

The contact and separation of the satellites was exquisite, from the first protruding interruption of the primary's periphery, to the bead-like form just touching, and finally their excision by the thread-like line of sky.

When all the three satellites were *in transitu* the shadow of the third was distinctly seen to be larger than the fourth, and the first the smallest of the three. This was perceptible to an observer who knew not that this was exactly in accordance with the relative size of the satellites.

The belts of *Jupiter* also were well exhibited: the two equatorial as the darkest; the Polar cap (extending some way down to the light band) in more delicate shade, while the corresponding Antarctic region was broken up into a smaller cap of a similar lighter colour, and a stratum of cloud intervening between it and the great southern light band.

Soon after the commencement of the transit of the third satellite on the eastern disk of the planet (but subsequent to the eclipse of the second on the western edge), I noticed two spots instead of one, and had not the first and fourth been still at a distance to the east of *Jupiter* I should have considered that two satellites (instead of one) were traversing the primary. This duplicity soon afterwards ceased to be visible.

When, however, all three satellites were together passing over *Jupiter* (with the fourth far in advance of the first), the phenomenon was again observed with respect to the first, and for a much longer period.

While the first was passing along (and just above) the lower equatorial belt, another dark spot followed it below the same belt. This lower spot, however, was visibly smaller than the upper one, and I think I recollect that their relative positions altered during the transit. When the transit was reached half way across the planet, the spots were not so decidedly seen (owing, doubtless, to the great rotundity of *Jupiter's* equatorial regions), and gradually became indiscernible.

But on the egress of the transit of this the first moon, it became evident which was the substance and which the shadow. I found that the upper one (and not the lower) was

the real satellite which had indeed overtaken and left the fourth still on *Jupiter's* disk.

I did not remark any duplicity connected with the fourth satellite; but it may be worth observing that the paths of the first and third across their primary were not very dissimilar (above and partly on the upper portion of the great southern dark belt), while that of the fourth was along the lower part of the same belt.

The transits of the first and second satellites of *Jupiter* were observed on the evening of the 16th of September. The passage of the first satellite was scrutinised for some way on the primary's disk, *but the shadow never at this transit assumed that remarkable duplicity* which it presented on the 21st August as described above.

Endsleigh Observatory,
Lansdowne, Bath.

On the partial Lunar Eclipse, 13*th Sept.* 1867.
By C. H. Weston.

There were a few points of interest connected with the lunar eclipse which may deserve a passing notice.

Firstly. Respecting colour of parts eclipsed; the prevailing colours were red-bluish and grey and grey. The redness increased towards the *darkened edge* of the Moon.

I did not (as in former eclipses) notice this colour at the boundary line where the Earth's shadow impinges on the Moon; but, on the contrary, it was confined to the *opposite* eclipsed region, deepening as it approached the northern parts, and attaining its greatest depth at the Moon's periphery. This was strikingly observable when the eclipsed portion was alone in the field of view. That these effects did not result from any chromatic errors was proved by using different telescopes and powers.

These colours and their relative positions differed entirely from those presented in the partial eclipse of Feb. 1858.

Secondly. Even during the eclipse *Aristarchus* exhibited its characteristic (though modified) *resplendent whiteness* which contrasted remarkably with the general gloom of the lunar surface. The details of the Moon were beautifully visible during the various gradations of the eclipse shadow.

Thirdly. The illuminated part of the Moon showed well its broken periphery in the mountainous tract of the S. E., S., and S. W.

Endsleigh Observatory,
Lansdowne, Bath, Sept. 16, 1867.

Note on the appearance of Jupiter, August 20th, 1867. By Mr. Hough.

The planet was examined by me several times between 8^h 30^m and 13^h 55^m G. M. T., but no observations were made of the times of ingress and egress on account of the great tremor of the planet's limb; it was, however, noticed that the fourth satellite was clear of the planet about five minutes before the time given in the *Nautical Almanac*. When the planet was best defined there were seen upon it the shadows of the first, third, and fourth satellites, and the disks of the the third and fourth. The disk of the third was bright and like a dew-drop, but that of the fourth seemed as dark as its shadow. Perhaps this was owing to the difference in the brightness of the two portions of the planet's disk on which the satellites were projected, the upper portion being white and the lower portion dusky brown.

The instrument employed was the 11-foot Equatoreal.

Wrottesley Observatory.

Memorandum on Preparations for Observing the Total Eclipse of the Sun on August 18, 1868. By Major J. F. Tennant.

In consequence of my paper on this subject, read at the Meeting of the Society on the 8th March last, the Council appointed a committee to further the project, and the instruments and methods were the subjects of considerable discussion. Eventually it was decided that there should be provided for Photography a silver glass reflector, equatorially mounted and driven by clockwork, and the Astronomer Royal offered to lend me (with the consent of the Admiralty) two telescopes from the Royal Observatory.

Estimates of the probable cost of the instruments having been obtained, they were submitted by the Astronomer Royal to the Secretary of State for India on the 15th June. On the 15th July I received through Mr. Airy a sanction for the estimated expense, and the instruments were ordered on the same day. Within a day or two I called at the India Office regarding the personal for the proposed operations, and submitted an estimate of the probable expense on the 23rd July, having previously ascertained that there would be no difficulty in obtaining such men as I wanted from the Royal Engineers. To this estimate I have as yet received no sanction.

I now proceed to the instruments and my proposed proceedings.

First as to *Photography*. It was found that the conditions as to time rendered it unadvisable to attempt the use

of a speculum of more than $9\frac{1}{2}$ inches diameter. This size has therefore been determined on. The picture will be taken at the side of the tube (the telescope being Newtonian), and provision is made both in the plane mirror and tube to insure an equally lighted field of upwards of a degree in diameter, in the hope that some traces of the structure of the corona may be obtained in the photographs. Unfortunately there have been very great and unavoidable delays with this instrument. The low latitude in which it has to be used, and the arrangements for Photography, have rendered a new design of almost every part necessary, and have, of course, entailed new patterns for all the castings. In making these changes, decisions have had to be made on various points of detail; and it is only due to Mr. De La Rue to express my obligations to him, not only for his advice, but for opportunities of seeing the operations of Photography, and trying some experiments with his instrument.

Polarization. The previous results in this matter have been so contradictory, that I have been anxious to obtain some simple test which shall not be liable to be misinterpreted, and to provide the means besides of verifying its indications. The instrument to be used is a 42-inch telescope, mounted firmly with an altitude-and-azimuth motion, which has been lent by the Astronomer Royal. For this a Ramsden eye-piece has been constructed carrying the proposed apparatus. This consists of an arrangement by which the plane of polarization can be determined in three ways.

1st. By the extinction of the polarized portion of the light by means of a Nicol's prism, reducing the intensity of the image to a minimum.

2nd. By Savart's test where parallel fringes are formed by the interference of the polarized rays, the centre one being either dark or light as its plane is in or perpendicular to the plane of polarization.

3rd. By a Double-image Prism and Analysing Plate, giving images of complementary colours with polarized light, in using which the field of view is bounded by a stop in the common focus of object-glass and eye-piece.

The first two of these tests can be instantaneously interchanged, and there is no difficulty in using all the tests successively in two minutes. There is in the focus of the object-glass a wire whose position with respect to the telescope can be determined by graduations, and to which all the tests are so adjusted, that in every case when the test phenomenon is at its maximum, the wire represents the plane of polarization. This wire also serves as an index to the central band in Savart's test, in which it is included. This is of importance, because, though in the case of a nearly white object where nearly all the light is polarized, the central band alone is unfringed with colour, and the intensity of the fringes rapidly

decreases; yet when the object is highly coloured, and especially if only a small percentage is polarized, it is not easy to distinguish this band without very close attention. I believe myself this will be the most useful test, but it will be seen that its indications can be verified.

Spectrum Observation. The Astronomer Royal has lent me one of the old collimators of the Transit Circle. For this an equatorial mounting is being made sufficient to follow any object steadily, but without clockwork. The spectroscope will allow of the spectrum being compared with a scale of equal parts, by means of which its peculiarities can be referred to the lines of the solar spectrum. At the suggestion of the Astronomer Royal, an arrangement has been made by which the spectrum can be observed in a bright field, which, however, can be instantaneously changed to a dark one. I am very doubtful if this bright field can be of any use, but the object under inspection can be identified by means of a finder, so that there will be no doubt.

It is proposed that instruments having reached India should be erected in a favourable place at or near Guntoor, where experiments can be carried on to ensure the success of the photographic operations. To assist me I propose to take out three non-commissioned officers of the Royal Engineers, on whom all the mechanical portion of the Photography will devolve; and it is most fortunate that the central line passes close to places so favourable as Guntoor and Masulipatam, where we shall have to reside some time; but for this circumstance such arrangements could hardly have been made.

Captain Branfill (an officer of the Indian Survey) will assist me by taking charge of the Polarization apparatus, and I hope to have some further aid from Colonel Walker's establishment. Colonel Thuillier, the Surveyor General, will be requested to lend me from his stores one or two chronometers and any further small aid I may need in instruments.

All these preparations will, however, be useless, unless the necessary remaining expense is sanctioned. It is, therefore, fortunate that the Royal Society intend, it is understood, to make arrangements for securing results on the Spectrum and Polarization.

London, Oct. 4, 1867.

Oct. 14. Since writing this I have received sanction for the proposed expenses.

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To the Catalogue of the Library of the Royal Astronomical Society.

Academy of Sciences of the Institute of France, Comptes Rendus, tomes lxi., lxii., lxiii., pt. 1, 4to. *Paris*, 1866	The Academy.
Airy, G. B., an Elementary Treatise on Partial Differential Equations, designed for the use of Students in the University, 8vo. *London and Cambridge*, 1866	The Author.
Almanacs, ten old, 1678 to 1813, 12mo. *London, v.y.*	S. Phillips, Esq.
American Ephemeris and Nautical Almanac for 1867, 8vo. *Washington*, 1865	The American Government.
American Philosophical Society, Proceedings, vol. x. 75, 8vo. *Philadelphia*, 1866	The Society.
——————— Catalogue of Library, pt. ii., 8vo. *Philadelphia*, 1866	——
American Academy of Arts and Sciences, Proceedings, vol. vi., vol. vii. Nos. 1 to 12, 8vo. *Boston and Camb. U.S.* 1865	The Academy

The Amsterdam Academy. — Amsterdam Royal Academy, Verslagen en Mededeelingen, Tweede reeks, 8vo. *Amsterdam*, 1865

—— ———————— Jaarboek, voor 1865, 8vo. *Amsterdam*, 1865

The Amsterdam Royal Academy. — Amsterdam Royal Academy of Sciences, Processen Verbaal van de gewone Verganderingen Afdeeling Naturkunde van Januarii 1865 tot en met April 1866, 8vo. *Amsterdam*

—— ———————— Catalogus van de Boekerij, 8vo. *Amsterdam*, 1866

S. M. Drach, Esq. — Anonymous, Heads of a Recent Discussion between a Learned Doctor in Divinity and the author of "Commentaries on the Principia of Sir Isaac Newton," 8vo. *London*, 1847

The Author. — Astrand, J. J., Enkel Approximations-method för tids och Longituds bistämnengar af, 8vo. 1866

Dr. Bache. — Bache, A. D., Standard Places of Fundamental Stars, U.S. Coast Survey, 4to. *Washington*, 1866

Sir J. Lubbock. — Bagay, V., Nouvelles Tables Astronomiques et Hydrographiques, 4to. *Paris*, 1829

The Author. — Bashford, Francis, Description of a Chronograph adapted for Measuring the varying Velocity of a Body in Motion through the Air, and various other purposes, 8vo. *London*, 1866

The Society at Batavia. — Batavia, Naturkundig Tijdschrift voor Nederlandsch Indie, Deel 28, 29, 8vo. *Batavia*, 1865

The Author. — Bauernfeind, Maximilian, Die Bedeutung moderner Gradmessung, 4to. *Munchen*, 1866

—— Bayma, Josh., The Elements of Molecular Mechanics, 8vo. *London and Cambridge*, 1866

The Berlin Academy. — Berlin Royal Academy of Sciences, Monatsbericht, Feb. to Oct. 1866, 8vo. *Berlin*, 1866

—— ———————— Abhandlungen, 1865, 4to. *Berlin*, 1866

Berlin, Astronomisches Jahrbuch 1869, 8vo. *Berlin*, 1867	Dr. Foerster.
Berlin Society of Physics, Die Fortschritte der Physik 1864, 8vo. *Berlin*, 1866	The Society.
Béron, Pierre, Taches Solaires et Périodicité de leur Nombre, 8vo. *Paris*, 1866	The Author.
——— Le Grand Soleil visible au Centre du Système du Monde, 8vo. *Paris*, 1866	——
——— La Physique Céleste, 8vo. *Paris*, 1866	——
Birt, W. R., Outline Lunar Map, zones ii. and iv. with Catalogue of 203 Objects, 8vo. *London*, 1867	W. R. Birt, Esq.
Brahe, Tycho, Observationes Septem Cometarum ex Libris Manuscriptis qui Hauniæ in Magna Bibliotheca regia adservantur, nunc primum edidit F. R. Fries, 4to. *Hauniæ*, 1867	The Editor.
British Association, Report, Birmingham, 1865, 8vo. *London*, 1866	The British Association.
Brussels Royal Academy, Mémoires, tome xxxv., 4to. *Bruxelles*, 1865	L'Academie Royale de Belgique.
——— Mémoires Couronnées et autres Mémoires, tome xviii, 4to. *Bruxelles*, 1865	——
——— Bulletins, 1866, 8vo. *Bruxelles*, 1866	——
——— Annuaire, 1866, 12mo. *Bruxelles*, 1866	——
Brussels Royal Observatory, Annuaire, 1866, 12mo. *Bruxelles*, 1865	——
Calcutta Public Library, Report for 1865, 8vo. *Calcutta*, 1866	The Library.
Chacornac, M., Recherches d'Astronomie Physique, sheets lithographed.	The Author.
Chambers, G. F., Descriptive Astronomy, 8vo. *Oxford*, 1867	——
Cherbourg Imperial Society, Mémoires, tomes xi., xii., 8vo. *Paris and Cherbourg*, 1865–6	The Society.

The Society. Christiania Observatory, Meteorologiske Jagttagelser, 1865, ob. folio *Christiania*, 1866

The University. Christiania Royal University, Aarsberetnung for Aaret 1864, 1865, 8vo. *Christiania*, 1865–6

The Secretary of State for War. Clarke, A. R., Comparisons of the Standards of Length of England, France, Russia, Belgium, Prussia, India, Australia, made at the Ordnance Survey Office, Southampton, 4to. *London*, 1866

The Meteorological Committee, Bengal. Cyclone, Report of the Calcutta Cyclone, Oct. 5, 1864, 8vo. *Calcutta*, 1866

The Author. Davies, S. M., The Meteoric Theory of Saturn's Rings, considered with reference to the Solar Motion in Space, 8vo. *Dublin*, 1867

S. M. Drach, Esq. Deichmann, A. H., New Tables to facilitate the Practice of Great Circle Sailing, 8vo. *Hanover*, 1856

The Authors. De La Rue, W., Stewart, B., and Loëwy, B., Researches on Solar Physics, second series, 4to. *London*, 1866

The Author. Delaunay, Ch., Théorie du Mouvement de la Lune, tome ii., 4to. *Paris*, 1867

The Publishers. Dietrichsen and Hannay's Royal Almanac for 1867, 8vo. *London*, 1866

The Author. Döllen, W., Jahresbericht am 19 Mai, 1865, dem Comité der Nicolai Hauptsternwarte abgestaltet in Vertretung des Directors der Sternwarte, 8vo. *St. Petersburg*, 1865

S. M. Drach, Esq. Douglas, Geo., An Appeal to the Republic of Letters in behalf of injured Science from the opinions and proceedings of some Modern Authors of Elements of Geometry, 8vo. *Edinburgh*, 1810

The Society. Edinburgh Royal Society, Transactions, vol. xxiv., part ii., 4to. *Edinburgh*, 1866

—— ———————— Proceedings, Session 1865–66, 8vo. *Edinburgh*, 1866

Flammarion, Camille, Etudes et Lectures sur l'Astronomie, 12mo. *Paris*, 1867	The Author
——— Changement arrivé sur la Lune, Le Cratère de Linné, 4to. *Paris*, 1867	——
Fritz, H., Die Perioden der Sonnenflecken der Polarlichtes und des Erdmagnetismus, 4to. *n.p. n.d.*	The Author
Gautier, A., Extrait des derniers publications de la Société Royale Astronomique de Londres, 8vo. *Génève*, 1866	——
——— Review of "Expériences faites à Génève avec le Pendule à reversion, par M. le Prof. E. Plantamour," 8vo. *Génève*, 1866	——
Geiser, C. F., Beitrage zur synthetischen Géométrie, 8vo. *Zurich*, 1866	——
Geneva Physical Society, Mémoires, tome xviii., 2[de] partie, 4to. *Génève*, 1866	The Society
Glasgow University, Report of the Professor of Astronomy, 8vo. *Glasgow*, 1867	Prof. Grant
Göttingen Royal Society of Sciences, Abhandlungen, vol. xii., 4to. *Göttingen*, 1866	The Gottingen Society.
——— Geleherte Anzeigen, 1866, vols. i., ii., 8vo. *Göttingen*, 1866	——
——— Nachrichten, 1866, 8vo. *Göttingen*, 1866	——
Gould, B. A., Reduction of the Observations of Fixed Stars made by Joseph Le Paute D'Agelet at Paris in 1783–85, with a Catalogue of the Corresponding Mean Places referred to the Equinox of 1800·0, 4to. *Washington*, 1866	The Author
Greenwich Royal Observatory, Astronomical, Magnetical, and Meteorological Observations in 1864, with Appendices and Results, 4to. *London*, 1866	The Lords Commissione of the Admiralty.
——— Report of the Astronomer Royal to the Board of Visitors, June 1, 1867, 4to. *London*, 1867	The Astronomer Royal.

The Author. Grove, W. R., Address to the British Association at Nottingham, August 22, 1866, 2nd edition, 8vo. *London*, 1867

The Publisher. Guillemin, A., The Heavens, translated by N. Lockyer, 8vo. *London*, 1866

The Author. Gylden, H., Untersuchungen uber die Constitution der Atmosphäre und die Strahlenberechnung in derselben, 4to. *St. Petersburg*, 1866

—— Hansen, P. A., Bestimmung des Langen- unterschiedes zwischen den Sternwarte zu Gotha und Leipsig unter seiner Mitwirkung ausgeführt von Dr. Auwers und Prof. Bruhns im April des Jahres 1865, No. II., 8vo. *Leipsig*, 1866

—— Heis, Dr. E., Grosse Feuer Kugel in der Nacht des 10–11 Mars, 1866, in Westfalen und Hannover, 8vo. *Halle*, 1866

Sir John Lubbock. Herschel, J. F. W., Results of Astronomical Observations at the Cape of Good Hope, 4to. *London*, 1867

The Commitee of Council on Education. Hofmann, A. W., Report on the Chemical Laboratories in the Course of Erection in the Universities of Bonn and Berlin, 4to. *London*, 1816

The Author. Houel, G. J., Mémoire sur le developpement des Fonctions en Series périodiques au moyen de l'Interpolation, 4to. *Paris*, 1864

—— ———— Recueil des Formules et des Tables Numériques, 8vo. *Paris*, 1866

H.M.'s Government. India. Tables of Heights in the N.W. Provinces and Bengal determined by the Great Trigonometrical Survey of India by Spirit-levelling Operations to May, 1865, 8vo. *Roorkee*, 1866

The Academy. Irish Academy, Royal, Transactions, vol. xxiv., parts 3 to 8, 4to. *Dublin*, 1866, 7

—— ———— Proceedings, vol ix., part 4, 8vo. *Dublin*, 1867

Journals.	Institute of Actuaries, Nos. 64 to 67, 4to. *London*, 1866, 67	The Institute of Actuaries.
———	American Journal of Science and Art, Nos. 123 to 127, 8vo. *Newhaven (U. S.)*, 1866–67	The Editor.
———	Asiatic Society, Royal, Journal, vol. ii. part 2, No. 5, 8vo. *London*, 1867	The Royal Asiatic Society.
———	——————— Ceylon Branch, Journal, 1865–6, 8vo. *Colombo*, 1866	———
———	The Astronomical Register, Nos. 43 to 54, 8vo. *London*, 1866–67	S. Gorton, Esq.
———	Astronomische Nachrichten, Nos. 1587 to 1642, 4to. *Altona*, 1866–67	Dr. Peters.
———	The Athenæum Journal, Nos. 2015 to 2067, 4to. *London*, 1866–67	The Editors.
———	The Canadian Journal, Nos. 62–63, 8vo. *Toronto*, 1866	The Canadian Institute.
———	Cosmos, v. n., 8vo. *Paris*, 1866	The Editor.
———	Franklin Institute, Journal, No. 486 to 497. *Philadelphia*, 1866–67	The Institute.
———	Geographical Society, The Royal, Journal, vol. xxxv., 8vo. *London*, 1866	The Royal Geographical Society.
———	——————— Proceedings, vol. x., No. 4, to vol. xi., No. 2, 8vo. *London*, 1866	
———	Geological Society, Quarterly Journal, Nos. 87 to 90, 8vo. *London*, 1866–67	The Society.
———	Herapath's Railway Journal, Nos. 1410 to 1461, 4to. *London*, 1866–67	J. Herepath, Esq.
———	The Horological Journal, Nos. 95 to 106, 8vo. *London*, 1866–67	The Horological Institute.
———	The Intellectual Observer, Nos. 54 to 65, 8vo. *London*, 1866–67	The Editor.
———	The London Review, Nos. 310 to 342, folio. *London*, 1866–67	———

The Editor. Journals. Le Moniteur Scientifique, v. n., 8vo. *Paris*, 1866–67

Dr. Francis. ——— The Philosophical Magazine, Nos. 213 to 225, 8vo. *London*, 1866–67

The Society. ——— The Photographic Journal, Nos. 170 to 180, 8vo. *London*, 1866–67

The Editor. ——— The Quarterly Journal of Science, Nos. 11 to 14, 8vo. *London*, 1866–67

The R. United Service Institution. ——— Royal United Service Institution, Journal, Nos. 38 to 42, 8vo. *London*, 1866–67

The Society of Arts. ——— Society of Arts, Journal, Nos. 707 to 759, 8vo. *London*, 1866–67

The Author. Kaiser, F., Verslag van den Staat der Sterrewacht te Leeden en van de Aldaar volbragte Werkzaamheden in het Zijdvak van die eersten Julii tot de laaste dagen der maand Junii, 1866, 8vo. *Amsterdam*, 1866

The Kazan University. Kazan University, Transactions for 1863, 4, 5 (in Russian), 8vo, and 4to. *Kazan, v.y.*

The Author. Kennelly, D. J., Notes on the Earthquake of 29 April, 1864, in the N.W. part of the Bombay Presidency, 8vo. *Bombay*, 1864

Sir John Lubbock. Kirchhoff, G., translated by H. E. Roscoe, Researches on the Solar Spectrum and the Spectra of the Chemical Elements, 4to., part 1. *Cambridge and London*, 1862

The Observatory. Königsberg Observatory. Astronomische Beobachtungen von Dr. E. Luther, folio. *Königsberg*, 1865

The Author. Krueger, A., Untersuchung uber die Bahn des Planeten Themis nebst eines neuen Bestimmung der Anzeihung des Jupiter, 4to. *Helsingfors*, 1866

——— Lamont, J., Verzeichniss von 9412 Æquatoreal Sternen zwischen + 3° und — 3°, Declination welche in den Munchener Zonen-Beobachtungen vorkommen reducirt auf den Anfang des Jahres 1860. Nebst Vergleichung mit den Beobachtungen von Lalande, Bessel, Rumker, und Schjellerup. V Supplement-Band zu den Annalen der Munchener Sternwarte, 8vo. *Munchen*, 1866

Lancashire and Cheshire Historic Society, Transactions, N.S., vol. v., 8vo, *Liverpool*, 1866 — The Society.

La Place, Précis de l' Histoire de l'Astronomie, 8vo. *Paris*, 1821 — Sir John Lubbock.

Leipsig Royal Society of Sciences, Berichte über der Verhandlungen der, 8vo. *Leipsig*, 1866 — The Leipzig Royal Society.

Liais, Emm., Traité d'Astronomie appliquée à la Géographie et à la Navigation, suivi de la Géodésie pratique, 8vo. *Paris*, 1867 — The Author.

Liebig, Justus F. von, Die Entwicklung der Ideen in der Naturwissenschaft, 4to. *München*, 1866 — ——

Littrow, Karl von, Ein Merkwurdiger Regenbogen, 8vo. *Wien*, 1862 — ——

———— Physische Zusammenkünfte der Planeten 1 bis 42 während der nächsten Jahre, 8vo. *Wien, v. y.* — ——

———— Physische Zusammenkünfte der Asteroiden im 1861, 2, 3, 4, 5, 6, vi. parts, 8vo. *Wien, v. y.* — ——

———— Physische Zusammenkünfte der Planeten Amphitrite and Melpomene in November, 1857, 8vo. *Wien*, 1857 — ——

———— Die Culminationspunkte der Ostlichen Central-Alpen, 8vo. *Wien*, 1853 — ——

———— Uber Luftspiegelungen, 8vo. *Wien*, 1862 — ——

———— Uebersicht des Planetensystemes, 2 parts, 8vo. *Wien*, 1864 — ——

———— Die Sonne, 8vo. *Wien*, 1864 — ——

———— Astronomische Miscellen. 2 parts, 8vo. *Wien*, 1866–7 — ——

Littrow, Otto von, Ueber eine neue Enrichtung des Spectralscopes, 8vo. *Wien*, 1863 — ——

———— Ueber einen Heliostaten nach Augusts Princip, 8vo. *Wien, n. d.* — ——

The Royal Lombardic Institute. Lombardy, Royal Institution. Memorie de Scienze e Lettere, Classe de Scienze Matimatiche e Naturali, vol. x. fasc. ii. 4to. *Milano*, 1865

—— Rendiconto, f. 3 to 8, 8vo. *Milano*, 1865–6

The Author. Luther, E., Das Klima von Konigsberg, 4to. *Konigsberg*, 1844

The Lords Commissioners of the Admiralty. Maclear, Sir Thomas, Verification and Extension of Le Caille's Arc of Meridian at the Cape of Good Hope, 2 vols., 4to. *London*, 1866

The Observatory. Madrid Royal Observatory, Anuario, an vii. 1866, 8vo. *Madrid*, 1865

—— —— Resumen Observaciones Meteorologicas, 8vo. *Madrid*, 1866

—— —— Libros del Saber de Astronomia del Rey D. Alfonso X. de Castilla, t. iv. folio. *Madrid*, 1866

The Author. Mailly, E., Essai sur les Institutions Scientifiques de la Grande Bretagne et de l'Irlande, 8vo. *Bruxelles*, 1867

The Society. Manchester Literary and Phil. Society, Memoirs, 3rd series, No. ii., Proceedings, vols. iii., iv., 8vo. *Manchester*, 1866

Mrs. Maynard. Maynard, Saml., A MS. Treatise on Chronology, folio.

The Meteorological Society. Meteorological Society, Proceedings, Nos. 25 to 31, 8vo. *London*, 1866–67

The Munich Academy. Munich Academy of Sciences, Sitzungsberichte, 1866, v. n., 8vo. *München*, 1865

The Lords Comm. of the Admiralty. The Nautical Almanac for 1870, 8vo. *London*, 1866

The Smithsonian Institution. Newcomb, Simon, An Investigation of the Orbit of Neptune with general Tables of its Motion, 4to. *Washington*, 1866

The Author. —— On the Latitude and Longitude of the U. S. N. Observatory, Washington, 4to. *Washington*, 1866

Newton, H. A., On certain Recent Contributions to Astro-Meteorology, 8vo. *Philadelphia*, 1867

O'Byrne, W. R., A Naval Biographical Dictionary, comprising the Life and Services of every Living Officer in her Majesty's Navy, from the Rank of Admiral of the Fleet to that of Lieutenant inclusive, 8vo. *London*, 1829 — S. M. Drach, Esq.

Palermo, Bulletino Meteorologico del R. Osservatorio, vol. ii. No. 3, fol. *Palermo*, 1860 — The Observatory of Palermo.

——— Instituto Tecnico, Giornale de Scienze Naturali ed Economiche, vol. i. fasc. 3 e 4, 4to. *Palermo*, 1866 — The Institute at Palermo.

Paris Imperial Observatory, Annales, Mémoires, tomes vii. viii.; Observations, vi. to x. and xviii. to xx., 4to. *Paris*, *v. d.* — The Imperial Observatory.

——— Atlas Ecliptique, 24 sheets. — ———

Parker, Franke, The Athenian Year and its bearing on the Eclipses of Thucydides and Ptolemy, and the Metonic Cycle, 8vo. *London*, 1866 — The Author.

Petermaritzburg, Meteorological Observations during the year 1865, fol. — Dr. Mann.

Petersburg, St., Imperial Academy of Sciences, Bulletins, tome ix., Nos. 1–4, folio. *St. Petersbourg*, 1866 — The Imp. Academy.

——— Mélanges Mathématiques et Astronomiques, tome iii.: — ———

Ephemeriden der beiden Bielaschen Cometen fur die Erscheinung, 1865–66, von T. Clausen.

Berechnung der Bahn des Cometen 1861, III., von V. Fuss.

Untersuchungen uber den Doppelstern Σ. 3121, von H. Fritsche.

Endeckung einiger schwacher Nebelflecke, von O. Struve.

Observations et Orbite de l'étoile double Σ. 1728 = 42 Comæ Ber., par O. Struve, 8vo. *St. Petersburg*, 1866

——— Imp. Observatory, Jahresbericht am 17 Mai 1866, dem Comité der Nicolai Hauptssternwarte, 8vo. *St. Petersburg*, 1864 — M. O. Struve.

The Academy. Philadelphia, Academy of Natural Sciences, Proceedings, Nos. 1 to 4, 8vo. *Philadelphia*, 1866

The Society. Philological Society, Transactions, 1864, 8vo. *London*, 1865

The Author. Plantamour, E., Resumé Météorologique de l'année 1865, 8vo. *Génève*, 1866

—— ———— Expériences faites à Génève avec le Pendule à reversion, 4to. *Génève et Basle*, 1866

—— Proctor, R. A., The Handbook of the Stars, 8vo. *London*, 1866

—— Quetelet, A., Sciences Mathématiques et Physiques chez les Belges au commencement du XIX. Siècle, 8vo. *Bruxelles*, 1860

—— Quetelet, E., Sur la nouvelle étoile changeant de la Couronne boréale, 8vo. *Bruxelles*, 1866

Rev. W. R. Dawes. Regiomontanus, J., Astronomorum principis Ephemerides, 4to. *Venetia*, 1481

The Collegio Romano. Rome, Collegio Romano, Bulletino Meteorologico, No. 3, vol. v., Tavole Meteorologico, folio *Rome*, 1866

The Royal Society. Royal Society, Philosophical Transactions, vol. clvi., part 1, 4to. *London*, 1866

—— ———— Proceedings, Nos. 84 to 93, 8vo. *London*, 1866–67

The Institution. Royal United Service Institution, Library Catalogue, 8vo. *London*, 1865

The Observatory. San Fernando Observatory, Almanaque Nautico para 1868, 8vo. *Cadiz*, 1866

The Author. Schiaparelli, G. V., Intorno al Corso ad all' Origine probabile delle Stelle Meteoriche, Lettere ac P. A. Secchi, 4to. *Roma*, 1866

Schmidt, I. F. Julius, Beobachtung der Meteore in der Nacht des 13–14, Nov. 1866, 8vo. *Wien*, 1866

Scottish Society of Arts, Transactions, vol. vii., part 2, 8vo. *Edinburgh*, 1866 — Prof. C. P. Smyth.

Smithsonian Institution, Annual Report for 1864, 8vo. *Washington*, 1865 — The Institution.

Smyth, Prof. C. P., Notice of recent Measures at the Great Pyramid, and some deductions following therefrom; an Address delivered to the Royal Society, Edinburgh, at the request of the Council (anticipatory of a fuller publication), 4to. *Edinburgh*, 1866 — The Author.

———————— Notes of an Exhibition of a Series of Photographs, illustrating the Land of Egypt, the Great Pyramid, &c. &c., 8vo. *Edinburgh*, 1866 — ———

Sofka, Franz Octav, Die Kosmischen Abkühlungen im Meteorologisches Prinzip, 8vo. *Wien*, 1863 — ———

Struve, Otto von, Ubersight der Thätigkeit der Nicolai Hauptsternwarte während der ersten 25 Jahre ihres Bestehens, 4to. *St. Petersbourg*, 1865 — ———

Tasmania Royal Society, Results of Meteorological Observations made in Tasmania, from 1st January to 30th June, 1866, 8vo. *Hobart Town*, 1866 — The Society.

———————— Report for 1865, 8vo. *Hobart Town*, 1866 — ———

———————— Monthly Notices of Papers and Proceedings, 1865–66, 8vo. *Hobart Town*, 1866 — ———

Todd, Charles, Annual Report of the South Australian Observatory and Telegraphs, 1865, folio. *Adelaide*, 1865 — The Author.

United States, Dudley Observatory, Annals, vol. i., 8vo. *Albany*, 1866 — The Dudley Observatory.

———————— Naval Observatory, Astronomical and Meteorological Observations during the years 1863–64, 4to. *Washington*, 1865–66 — The Observatory.

Upsala Royal Society, Nova Acta, Series 3, vol. vi., 4to. *Upsaliæ*, 1865 — The Society.

The Society. Upsala, Universitats Arsskrift, 1865, 8vo. *Upsala*, 1865

The Victoria Royal Society. Victoria Royal Society, Transactions and Proceedings, January 1865 to June 1866, vol. vii., 8vo. *Melbourne*, 1866

The Imp. Academy. Vienna Imperial Academy of Science, Denkschriften, vol. xxv., 4to. *Wien*, 1866

—— ———————— Sitzungsberichte, v. n. for 1866, 8vo. *Wien*, 1866

The Observatory. ——— Imperial Observatory, Annalen. Jahrgang 1863, 8vo. *Wien*, 1866

—— ———————— Meteorologische Beobachtungen von 1775, bis 1835, Funfter Band, 1839–55, 8vo. *Wien*, 1866

M. Von Littrow. ———————— Bericht der Commission über die Astronomische Preisfrage, 8vo. *Wien*, 1861

The Author. Winnecke, A., Pulkowaer Beobachtungen des Hellen Cometen von 1862, nebst einigen Bemerkungen, 4to.

—— Wolf, Rudolf, Astronomische Mittheilungen, No. xxii., 8vo. *Zurich*, 1867

The Society. Zoological Society, Transactions, vol. v., part 5, 4to. *London*, 1866

—— ———————— Proceedings, 1865, 8vo. *London*, 1866

—— ———————— Report of Council, 1866, 8vo. *London*, 1866

Prof. Wolf. Zurich, Schweizerische Meteorologische Beobachtungen unter Direction von Profr. Dr. Rudolf Wolf, 1864–6, 4to. *Zurich*, v. y.

Books, &c. purchased with the Turnor Fund.

Boole, Geo., A Treatise on the Calculus of Finite Differences, 8vo. *Cambridge*, 1860

Briggs, Henry, Tafel van Logarithmi voor de Ghetallen van een tot 10,000, 8vo. *Ter Good...* 172...

Eliacus, Peter de, Tractatus super libros Metheororū, De impressionibus Aeris ac de hiis quæ in prima: secunda: atque tertia regionibus Æris fiunt, sicut sunt Sydera cadentia Stellæ, Cometæ, Pluvia, Ros, Pruina, Nix, Grando, Ventus, Terremotus deque generatis infra Terram, 4to. *Argentinæ*, 1504

I. W., Sciographia, or the Art of Shadows, 8vo. *London*, 1635

Kepler, John, Opera Omnia, vol. vi., part 2, 8vo. *Frankfurti*, 1866

Manfredus, Eustachius, Ephemerides Motuum Cœlestium ex an. 1715 in an. 1750, 3 vols., 4to. *Bononiæ*, 1715–25

Muhamedis Alfragani Arabis Chronologica et Astronomica Elementa, Additus est Commentarius, Autore M. Jacobo Christmanno, 4to. *Frankfurti*, 1590

Petit, M., Traité d'Astronomie, 2 vols., 8vo.

Placido de Tetis, Tabulæ Primi Mobilis cum Thesibus ad Theorizen et Canonibus ad Praxim, 4to. *Patavii*, 1667

Schmidt, I. F. I., Uber der Rillen auf dem Monde, 4to.
Leipsig, 1566

Whewell, W., On the Plurality of Worlds, an Essay; also a Dialogue on the same subject, 12mo. *London*, 1859

MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY,

CONTAINING

PAPERS,

ABSTRACTS OF PAPERS,

AND

REPORTS OF THE PROCEEDINGS

OF

THE SOCIETY,

FROM NOVEMBER 1867, *TO JUNE* 1868.

VOL. XXVIII.

BEING THE ANNUAL HALF-VOLUME OF THE MEMOIRS AND PROCEEDINGS
OF THE ROYAL ASTRONOMICAL SOCIETY.

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MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. XXVIII. *November* 8, 1867. No. 1.

Rev. CHARLES PRITCHARD, M.A., President, in the Chair.

Thomas Michael Almond, Esq., Scarborough;
Samuel Courtauld, Esq., Gosfield Hall, Essex; and
Edwin Story, Esq., Alnwrah Road, Islington,

were balloted for and duly elected Fellows of the Society.

Volumes XXXV. and XXXVI. of the *Memoirs* are now published. Vol. XXXV., price to Fellows, 14*s*.; to the public, 25*s*. Vol. XXXVI. (without *Monthly Notices*) to Fellows gratuitously. Price of ditto (with *Monthly Notices*) to the public, 10*s*. Pursuant to a recent Resolution of the Council, each Fellow is entitled to receive a copy of Vol. XXXVI. and of every subsequent volume of the *Memoirs*, on *personal* application by himself or his agent, at the Apartments of the Society, provided that such application is made within three years from the end of the year in which the volume is published.

The Annual Parallax of Sirius deduced from North Polar Distances observed with the Transit-Circle at the Royal Observatory, Cape of Good Hope, 1856–1863. By Cleveland Abbe, Esq.

This fine series of meridional observations, of which 136 are direct and 12 reflexion, is divided as follows:—

1856	25 D	7 R	1858	4 D	1860	33 D	5 R	1862	21 D
1861	2 D		1859	2 D	1861	8 D		1863	41 D

The observers and the share that each has taken in the work are shown by the following:—

Sir Thomas Maclear	34 observations	T. D.	1 observation.
		G. C.	14 ,,
George Maclear	61 ,,	C. D. F.	25 ,,
William Mann	6 ,,	J. F.	7 ,,

The crude observations are not at hand, but instead thereof, a series of corresponding mean N. P. D.'s for the beginning of each year; these numbers are presumed to have been obtained by adding to the mean declination of the *British Nautical Almanac* the difference between the tabular and observed apparent declination. Nothing has been communicated concerning the methods of observation and reduction.

It is proposed to reduce these N. P. D.'s to the mean equinox of 1860·0, using the variable proper motion resulting from the investigations of Dr. Auwers, as published in No. 1506 of the *Astronomische Nachrichten*. Dr. Auwers has given his results in the form of corrections to the mean distances of Bessel's *Tabulæ Regiomontanæ*, using Zech's continuation of the *Tab. Reg.* for 1850–1860, and Wolfers' *Tabulæ Reductionum* for 1860–1880, minus the corrections given in his Introduction. We thus receive the following system of mean declinations:—

	Auwers.		British Naut. Alm.	
Year.	Mean δ,	Red. to 1860·0.	Mean δ,	Red. to 1860·0.
1856	−16° 31′ 19″·231	−18″·923	−16° 31′ 19″·70	−18″·46
1857	23·953	−14·201	24·32	−13·84
1858	28·682	− 9·472	28·93	− 9·23
1859	33·417	− 4·737	33·54	− 4·64
1860	38·154	0·0	38·16	0·0
1861	42·898	+ 4·744	42·78	+ 4·62
1862	47·644	+ 9·490	47·40	+ 9·24
1863	52·391	+14·237	52·03	+13·87

The mean δ from the *Nautical Almanac* for 1856 has received the correction $+0''{\cdot}02$ to reduce it to Jan. 0 ⊙ = 280°. The

comparison of the annual variations deduced from the declinations of Auwers and the *Almanac* shows that we must add to each individual mean declination the correction $+0''.12\,\tau$, in order to reduce it to the beginning of the year with Auwers' proper motion We thus have as the foundation of further investigations,

Given mean δ + ($0''.02$ for 1856) + $0''.12\,\tau$ + Auwers' Reduction to 1860.0
$= -16^\circ\,31'\,36''.20$ + function of parallax and other unknown quantities.

Our first inquiry should now be, how far the given observations are free from constant errors that will undermine the security of any resulting value of the desired Parallax. Knowing but little of the methods pursued by the different observers, it is evident that each must be supposed to have a different constant error, whilst the corrections to the proper motion and the constant of aberration should be zero. The correction of the thermometer coefficient in the refraction will be assumed zero for want of proper material to determine it. Our equations of the condition should therefore be of the form

$$\text{Mean } \delta\ 1860.0 = +16^\circ\,31'\,36''.20 + x_1 + x_2 + x_3 + x_4 + y\,[9.8065]\sin(\odot - 4^\circ.3) + z\,(t - 1860.0) + w\,[9.8065_n]\cos(\odot - 4^\circ.3)$$

or

$$0 = n + x_1 + x_2 + x_3 + x_4 + ay + bz + cw,$$

x_1, x_2, x_3, x_4 being the constant corrections for G.M., T.M., G.C., C.D.F., respectively: y the parallax, z the correction to the proper motion, w the correction to the aberration $20''.45$.

Our observations are not sufficient for the determination of so many unknowns, and we will make a first solution, omitting bz and cw. We have the following normals:—

$$\begin{aligned} 61\,x_1 - 1.32\,y + 8.71 &= 0 \\ 34\,x_2 + 8.35\,y - 2.00 &= 0 \\ 14\,x_3 - 4.99\,y + 4.06 &= 0 \qquad [nn] = 104.21 \\ 25\,x_4 - 7.19\,y - 23.25 &= 0 \\ -1.32\,x_1 + 8.35\,x_2 - 4.99\,x_3 - 7.19\,x_4 + 33.61\,y - 1.72 &= 0 \end{aligned}$$

whence I.

$$\begin{aligned} x_1 &= -0''.136 \quad \pm 0.058 \\ x_2 &= +0.006 \quad .080 \\ x_3 &= -0.209 \quad .124 \\ x_4 &= +0.995 \quad .093 \\ y &= +0.227 \quad .084 \end{aligned}$$

Prob. error of one observation $= \pm 0.450$

The observations of Mr. George Maclear are also alone suf-

ficiently numerous to authorise an independent solution. We have the normals

$$61\,x_1 - 1{\cdot}32\,y + 8{\cdot}71 = 0$$
$$-1{\cdot}32\,x_1 + 15{\cdot}47\,y - 6{\cdot}99 = 0 \qquad \text{II.}$$

whence

$$x_1 = -0{\cdot}133$$
$$y = +0{\cdot}440$$

The computation of the residual errors from the solution I. gives us

Prob. error	1 observation	G. M.	61 obs.	$\pm 0''{\cdot}46$
		T. M.	34	0·26
,,	,,	G. C.	14	0·39
		C. D. F.	25	0·78
,,	,,	C. D. F.	24	0·65

This second value for C. D. F. being found by omitting the observation of 1863, Jan. 21, whereof the discordance $-3''{\cdot}46$ is much larger than should be attributed to the accidental errors of good observers. We have in this solution given the same weight to all observers and observations. There are twenty-one cases in which the image of the star is noted as very bad, execrable, a mere blotch, &c. Collecting these, we find,

Prob. error	1 obs.	bad image	$\pm 0''{\cdot}50$
,,	1 obs.	ordinary	$\pm 0{\cdot}48$

The above Annual Parallax seems to be the most reliable that can be drawn from the given observations; and if we compare its value $+0{\cdot}227 \pm 0''{\cdot}084$ with that drawn from the observations of Maclear in 1836–37 by Dr. Gylden,* — viz., $+0''{\cdot}193 \pm 0''{\cdot}087$, we find the agreement sufficiently satisfactory. But the latter value is entitled to greater confidence, inasmuch as the zero point of the circle was eliminated by the direct and reflexion observations.

That constant errors have been present in the series now under consideration, and which may have exerted a prejudicial influence upon the resulting parallax, will be suspected from the following solution. We combine, namely, all the 148 observations, the equations of condition being of the form

$$0 = n + x + ay + bz + ew,$$

where the personal differences are considered as smaller than their probable errors.

* *Bulletin de l'Académie Impériale des Sciences de St. Petersbourg*, 1864, April.

We obtain then the following normals:—

$$
\begin{array}{rrrrrl}
148\,x & -10{\cdot}48\,y & +\;118{\cdot}52\,z & -28{\cdot}96\,w & -17''{\cdot}49 = 0 & \\
-\;10{\cdot}48 & +36{\cdot}55 & -\;\;62{\cdot}37 & +14{\cdot}62 & -\;0{\cdot}04 = 0 & \\
+118{\cdot}52 & -62{\cdot}37 & +1001{\cdot}58 & -17{\cdot}80 & -71{\cdot}97 = 0 & [nn] = 112{\cdot}32 \\
-\;28{\cdot}96 & +14{\cdot}62 & -\;\;17{\cdot}80 & +24{\cdot}36 & +\;8{\cdot}22 = 0 &
\end{array}
$$

whence III.

$$
\begin{array}{lll}
x = -0''{\cdot}029 & \pm 0''{\cdot}056 & \\
y = +0{\cdot}350 & \;\;{\cdot}116 & \\
z = +0{\cdot}078 & \;\;{\cdot}0201 & [nn\,4] = 102{\cdot}24 \\
w = -0{\cdot}517 & \;\;{\cdot}153 & \\
\text{Prob. error } 1 \text{ obs.} = & \pm 0{\cdot}562 &
\end{array}
$$

The large corrections to the aberration and proper motion, as well as the large parallax, may serve to render these results inadmissible. A portion of the entire change in the value of the parallax may be due to the large personal error of C. D. F. For the other observers our hypothesis $x_1 = x_2 = x_3$ may be admitted; and in general we may notice that the entire series will be better fitted to the determination of parallax and aberration if the year 1863 is omitted, as its observations are all included in the first three months. Omitting these observations (including more than one half of those made by C. D. F.) and retaining the same unknowns, we have

$$
\begin{array}{rrrrrl}
1{\cdot}07\,x & +\;4{\cdot}88\,y & -\;\;9{\cdot}30\,z & -11{\cdot}35\,w & +0''{\cdot}78 = 0 & \\
+\;4{\cdot}88 & +28{\cdot}50 & -\;14{\cdot}75 & +\;9{\cdot}37 & -8{\cdot}95 = 0 & [nn] = 50{\cdot}191 \\
+\;9{\cdot}30 & -14{\cdot}75 & +602{\cdot}68 & +37{\cdot}49 & -9{\cdot}84 = 0 & \\
-11{\cdot}35 & +\;9{\cdot}37 & +\;37{\cdot}49 & +15{\cdot}62 & +0{\cdot}17 = 0 &
\end{array}
$$

whence IV.

$$
\begin{array}{lll}
x = -0''{\cdot}084 & \pm 0''{\cdot}046 & \\
y = +0{\cdot}560 & \;\;{\cdot}102 & \\
z = +0{\cdot}0622 & \;\;{\cdot}0210 & [nn] = 44{\cdot}59 \\
w = -0{\cdot}546 & \;\;{\cdot}154 & \\
\text{Prob. error } 1 \text{ obs.} = & \pm 0{\cdot}438 &
\end{array}
$$

The aberration and proper motion corrections being properly considered only as tests, unless we give attention to the newly published investigations of Dr. Klinkerfues, we shall derive our most reliable value of the unknowns x and y from the preceding equations, by neglecting the other two, z and w.

We thus have

$$
\begin{array}{llll}
x = -0''{\cdot}022 & & & \text{V.} \\
y = +0{\cdot}318 & \pm 0{\cdot}08 & [nn\,2] = 47{\cdot}33 &
\end{array}
$$

The proper result for parallax will, however, be that of solution I., or perhaps still better, a similar solution in which $x_1 = x_2 = x_3$ is assumed. We thus have

$$\begin{array}{llll} 109\,x_1 & & +\ 2{\cdot}04\,y & +10''{\cdot}77 = 0 \\ & 25\,x_4 & -\ 7{\cdot}19\,y & -23{\cdot}25 = 0 \qquad nn = 104{\cdot}21 \\ +204\,x_1 & \pm 7{\cdot}19\,x_4 & +33{\cdot}61\,y & -\ 1{\cdot}72 = 0 \end{array}$$

whence

$$\begin{array}{lll} x_1 & -0''{\cdot}102 & \pm 0''{\cdot}056 \\ x_4 & +1{\cdot}008 & 0{\cdot}132 \qquad [nn\,3] = 79{\cdot}17 \\ y & +0{\cdot}273 & 0{\cdot}102 \\ \text{Prob. error 1 obs.} & & \pm 0{\cdot}576 \end{array}$$

previously where we have neglected such constant errors as are manifested by the results of the III. and IV. solutions.

The result of our investigations is, therefore, to be considered as at least corroborative of the conclusion drawn by Mr. Henderson, as given in his Memoir in vol. xi. of the *Memoirs of the Royal Astronomical Society*, that "the parallax of *Sirius* is not greater than one-half of a second of space," the precise statement being

$$\pi = +0''{\cdot}27 \pm 0''{\cdot}10$$

Poulkova, May 1866.

On some newly discovered Stars near α Lyræ.
By J. Buckingham, Esq.

About four years since, during a visit by Mr. Hartnup, when looking through my 20-inch object-glass (made by Wray), which is mounted equatoreally, we perceived a very small, yet bright, star near *Vega*, which appeared precisely situated on an imaginary line from A to B, the well-known companion; but, owing to the state of the air, it could only occasionally be seen. It has been repeatedly verified since.

In the autumn of 1865 its brightness had much increased, and it was more easily seen than at the time of its discovery, yet not sufficiently so to be perceived with my 9-inch object-glass (also by Wray), which is as fine as possible, in my opinion, to be made; its focus is 14½ feet. This star *c* since the earlier part of August is fainter than before observed, and its position-angle has increased since its discovery, being now (November) to the S.W. of the former place, which was on the line from A to B, but now

sensibly to the apparent left of it, its distance appearing to be about $\frac{1}{8}$ that of B from A.

On the 10th May, 14^h P.M., 1867, with the same object-glass (20-inch) another small star *d* was perceived, about 90° or 95° greater in its position-angle than the star *c*; also rather more distant and not so bright as it; and only seen by glimpses during moments of fine definition; but I could not perceive either *c* or *d* with the 9-foot Equatoreal.

On July 19 last, my friend, the Rev. R. Crowe, of Huddersfield, was looking at *α Lyræ* through the 9-foot Equatoreal (driven by the Foucault clock), and had only a short time been so occupied when the star *c* was seen, of which he made a diagram by my request; and the estimated distance from A was $\frac{1}{7}$ of that of B. After a few more moments he perceived the star *d*, and placed its position on the previous diagram, when I showed him my own previous sketch, and they perfectly accorded so far as to be seen that they were the same objects. Mr. Crowe had not received the slightest intimation of my known positions; but to him they were "easily seen:" for myself, had I not known of the previous existence and positions, it is probable they would in this instrument have been overlooked. Although there was not the slightest perceptible tremor of the atmosphere, the images being absolutely steady, every known precaution was taken to avoid the chance of error, as various eye-pieces were used, and were rotated, as well as the object-glass; and the instrument was used several times on each side of the polar axis with like results. It was necessary to use powers of 250 and upwards, the two stars not being visible with lower ones; but being best seen with 440.

On August 10, 1867, some visitors (well-known good observers) looked through the new 21¼-inch object-glass. The air was rather unsteady, with considerable "flying scud," yet they each could see both stars *c* and *d*. They left about 11 P.M., as the atmosphere prevented further observation, it being entirely clouded over. Some time after they had left the Observatory, the night cleared up, and became brilliant,—perhaps more so than usual in my experienee,—and I was induced to go again to the large telescope to examine some nebulæ. After some time I again turned the instrument on *α Lyræ*, and directly perceived another new star *e*. As *a* entered the field of the eye-piece, it was north, preceding, at an angle about 295°, distance about 34 seconds or more of arc. It had at least three times the light of the others *c* and *d*, and was best seen with powers 630 and 850, appearing of purple tint; and about the brilliance of the pole-star companion in a 3-inch aperture and power 100, but it has since become brighter.

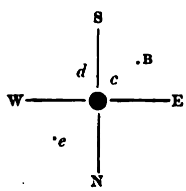
c is brighter than *d*, but they are both too faint for estimation of colour by myself, and can only be seen in a tolerably good state of the air; and I estimate their brilliance in the large object-glass as little exceeding that of the companion of *Polaris*, as seen

by myself with a power of 80 in an object-glass of 1·7 inch aperture,—that is, just steadily visible now (in November).

The few succeeding remarks may be necessary to show why the larger instrument was not used during Mr. Crowe's observations; having just had a new object-glass of 21¼ inches made, and for the purpose of testing its quality.

In the beginning of July last the former object-glass of 20 inches was taken out of its cell, which latter was temporarily adapted to the new and larger object-glass, which was tried on July 8th, and its performance being found excellent, with powers up to 1800, there being fine definition on suitable objects, as γ^2 *Andromedæ*, γ *Equulei*, δ *Cygni*, ζ *Herculis*, and the excessively faint double star near A and B *Capricorni*, I decided to alter the old tube and reduce its length to that of the new object-glass, viz. 25¾ feet; which alterations were not complete till July 28th; so that I had no larger instrument in use, at the time Mr. Crowe paid me a visit, than the 9-inch Equatoreal; but since the end of July, this 21¼-inch object-glass has been used on every night since that opportunity gave me, and its performance is very satisfactory on double stars; equally so on nebulæ; and in the "Dumb Bell" many stars are readily visible on its surface. The detail on the Moon is remarkable; the smaller satellites of *Uranus* are pretty bright: that of *Neptune* has been observed. The 5th and 6th stars in the trapezium of *Orion* are wonderfully bright objects, and the detail and brilliance of the nebula itself astonishing.

Rough Diagram of Positions.



The discovery of these minute points of light near a star, so often under the scrutiny of nearly every observer, will doubtless interest most of our Members, as there are many instruments in this country capable of reaching these specks under favourable circumstances, independently of any speculations as to their physical connexion with A; and the belief that a report of the performance of so large an object-glass of English manufacture would be desirable to be known to our Society, is my apology for the length of this communication.

November 8, 1867.

Description of an Observing Chair. By the Rev. W. R. Dawes.

I beg the Society's acceptance of a few copies of a photographic picture of an observing chair, which I contrived and had made some years ago. I have found it more convenient and useful than any other I have ever met with of moderate size and expense.

The general plan of its construction will be obvious from the picture. A few points may require a little further explanation.

The angle of the slanting upper part of the frame is about 30°. The left-hand slanting timber is notched throughout its length; and, attached to the sliding body composed of the seat and back, is a stout catch which falls into the notches as the chair is raised; and, when lifted up by the left hand of the observer, permits the chair to descend.

The back is supported by a stout quadrant of iron, toothed on the under side; and a catch is forced by a spring into the teeth as the back is raised, to support it at any convenient elevation. The catch can be easily pushed out of the teeth by the observer reaching behind him with one hand, while he diminishes the elevation of the back with the other.

On the right-hand side of the back is an arm which can be raised or lowered at pleasure, so as to prevent fatigue to the right arm by supporting the elbow, and to keep the hand steady in the management of the micrometer.

The angle which the slanting frame makes with the horizon is arranged so that when the seat is raised nearly to the top, the observer's eye may be at about the same height from the floor as it would be if he were standing. Of course, the angle may be varied with regard to the distance of the pillar of the equatoreal from the wall of the room, and to the height of the declination axis above the floor.

On the left side, attached to the upright timber near the middle of the frame, is a long and stout bolt, having a sharp point, which is so arranged as to be quite free from the floor when entirely drawn up, and so pierce the floor when forcibly pushed down. This enables the observer to *cast anchor*, and prevents the chair from being accidentally moved from the most convenient place.

The first chair of this kind was made at Wateringbury when I was residing there; but during my residence at Haddenham, several have been made here under my superintendence for some eminent observers. One of them is in the Royal Observatory at the Cape; and, as I have been informed, is highly esteemed by Sir Thomas Maclear; and one is now in hand for our Secretary, Mr. Huggins. The simplicity of their construction renders it almost impossible for them to get out of order, as is proved by the fact, that the first which was made, about fifteen years ago, and has

been in constant use the whole time, has never needed any repair, and now works as well as ever.

Hopefield Observatory, Haddenham, Bucks,
1867, *Nov.* 6.

P.S. To render the different parts more distinct, I have drawn the following sketches.

Fig. 1. Fig. 2.

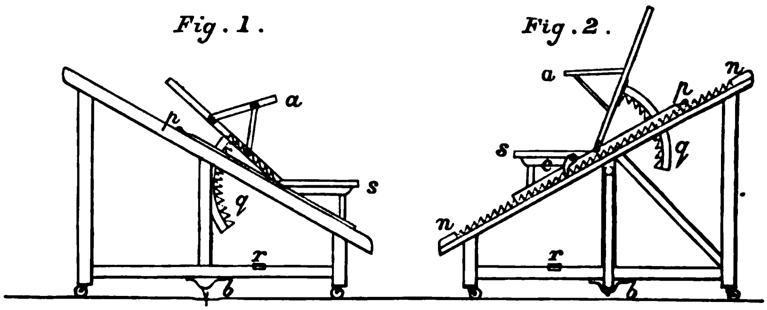


Fig. 1. *Right Side.*

a. Arm, for supporting the observer's elbow at any convenient height.
b. Bolt, for anchoring. Sharp point *pushed into floor.*
p. Pin, by pressing which the spring is pushed out of the teeth of the the *quadrant p.*
r. Rail across the lower frame for supporting the feet. May be removed if ever in the way of the iron quadrant *q.*

Fig. 2. *Left Side.*

a. See Fig. 1.
b. Bolt, as fixed on the middle upright timber; represented as *drawn up.*
c. Catch, which falls into the notches (*n n*) in the slanting timber, and supports the seat (*s*).
p. See Fig. 1.
q. Iron toothed *quadrant.*
r. See Fig. 1.

Jupiter without a visible Satellite. By the Rev. W. R. Dawes.

On the evening of August 21st, clouds prevented observations of the planet till the fourth satellite was very near the eastern edge of the disk. Its light was small and its colour rather ruddy. The first satellite, which was near it, had two or three times the light of the fourth. Clouds prevented observation of the entrance of the fourth upon the disk. It was a little past 10^h before the planet was moderately well seen. The third, fourth, and first satellites were then all visible on the disk, together with their shadows.

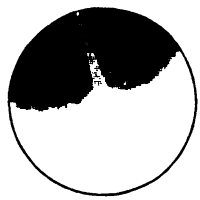
In the best state of the atmosphere I found power 412 the most efficient on my 8-inch refractor. Watching for the best

views with this power, I carefully examined each of the six objects visible on the disk.

Contrary to my expectation, the shadows of all the three satellites appeared to be equally black throughout. Not even on that of the fourth could I perceive any deviation from perfect blackness up to the very edge; and this precisely agrees with the results of all my previous observations; in which, however, I had not so carefully attended to this point. That there ought to be a sensible penumbra seems to be evident; but it has occurred to me since the observation, that the reason why it is not perceivable may be, that the edge of the shadow is in immediate contrast with the bright surface of the planet; and therefore, though not quite so black as its centre, it appears so by contrast.

The *fourth* satellite was so dark that I could not satisfy myself that it was decidedly less dark than its shadow. Nor could I be sure of any variation of tint in different parts of the satellite, or of any obvious deviation from perfect roundness. Indeed it could only be distinguished from its own shadow by its smaller size. That there should be no irregularities observable in the dark shade of this satellite surprised me much, as I have formerly noticed such without great difficulty.

The careful scrutiny of the *third* satellite furnished a very different result. The north-eastern side of it was remarkably bright, while the opposite side was nearly as dark as its shadow. Usually the satellite seemed to be about equally divided between the bright and dark portions; but during the finest views the true form of the dark part came out with satisfactory distinctness; and it then forcibly reminded me of the form which I had on more than one occasion depicted. (See *Monthly Notice*, April 1860, figs. 2 and 3). But it occupied an almost directly opposite part of the satellite, namely, the south-west instead of the north-east; thus,—



Occasionally the narrow white channel between the two dark protuberances was clearly seen, though by too transient views.

Hopefield Observatory, Haddenham, Bucks,
1867, Nov. 6.

P. S. The substance of this paper, with the illustrative sketch of the third satellite, has already appeared elsewhere, because it was important that, if possible, the remarkable appearance of the satellite should be looked for during every transit which would occur in the present apparition, by all observers who possess sufficiently powerful telescopes.

On Jupiter without Satellites exterior to his Disk.
By T. W. Burr, Esq.

Being desirous of witnessing the appearance above referred to, I visited my friend Mr. Slack, of Camden Square, N.W., on the night of August 21st, he having in his Observatory an excellent $6\frac{1}{2}$-inch silvered glass mirror, mounted equatoreally by Mr. Browning. Unfortunately the weather was most unfavourable,— dense masses of clouds obscuring the heavens; and it was not until nearly 10 o'clock that a break occurred, enabling us to see the planet with only one satellite (the 1st) remaining outside the disk. The shadows of two others (the 3d and 4th) were also seen projected on the southern equatoreal belt with another, not so well defined, object between them. Soon after 10 o'clock a second glimpse was obtained, and the 1st satellite seen just entering on the disk of *Jupiter*. A few more fleeting views were caught between $10^h 20^m$ and $10^h 30^m$, during which it was evident that the object seen between the shadows was the 3rd satellite itself; and that it was lighter in tint than the shadows, which were inky black, the satellite giving the impression of a browner colour. The shadow of the 1st satellite was also now visible, as black as the others, and not being thrown on a belt like those of the 3d and 4th, but on a clearer space, was very conspicuous. The clouds then closed up so thickly that no further observations could be made during the time the transits and occultation continued. Four spots, being three shadows and one satellite (the 3rd), were therefore distinctly seen, and, as I subsequently had a difficulty in localizing the shadow of the 1st satellite, my memory giving the impression of a spot both above and below the southern equatoreal belt, I have no doubt that at times I also perceived, in my hasty glimpses through the drifting clouds, the 4th satellite itself; which, if so, was as black as the shadows, and unlike the 3rd in its lighter tint. The power employed was 120, with the occasional change to 175; and the performance of the telescope, during the brief opportunities for observation, most excellent.

Islington, October 1867.

Determination of the Latitude of Kingston Observatory, Canada.
By the Rev. Dr. J. Williamson.

Having a portable transit 30 inches in length, I wished to employ it in correcting our roughly determined latitude; but our building not being fitted for observation in the prime vertical precluded the possibility of employing that method within doors,

while the situation of the Observatory, in a public park, was not such as to allow of using instruments out of doors. In this dilemma I resorted to the following method:—

The stand of the transit is supported by three foot-screws, one of which is directly beneath a Y of the instrument.

Beneath this foot-screw I adjusted a carefully made micrometer-screw, having a head divided into 100 parts.

I then determined the value of one division, partly by means of the level and partly by transits of stars, to be 0″·96.

I then carefully adjusted the instrument for collimation and placed the axis in the meridian as nearly as possible, the thread intervals being previously obtained.

I next computed from the B. A. C. the places of several stars which pass within a few minutes of our zenith, limiting myself to those which would be confined to the web of the transit, or nearly so. When one of these stars was upon the meridian I brought that wire of the instrument which was nearest to it to coincide with it by turning the micrometer-screw.

In this manner I determined the distance at which the star would, when culminating, pass from the middle wire of the instrument when in its zero position, and hence the latitude.

The results of the several observations for this purpose are given below.

Date. 1865.	Star. B.A.C.	Comps.	Ded. Latitude.	Weight.
June 8	4841	N	44° 13′ 26″·6	10
10	,,	S	24·7	8
12	5400	N	23·1	8
,,	4841	S	16·3	8
16	4841	S	17·6	7
19	5400	S	18·3	8
21	4841	N	20·7	10
22	4841	S	21·6	10
,,	5400	S	23·3	9
23	4841	S	23·3	10
Aug. 14	6731	S	21·9	10
15	6013	S	18·9	8
16	6013	N	24·7	7
19	6013	N	44 13 21·8	10

Giving a mean value

$$\phi = 44^\circ\ 13'\ 21''\cdot 7$$

with a probable error of 0″·7.

Occultations of Stars by the Moon, observed at Forest Lodge, Maresfield. By Capt. W. Noble.

(Previously unreported.)

Friday, January 18, 1867, Occultation of 26 *Geminorum.*

The Star disappeared instantaneously at the Moon's dark limb at $3^h\ 34^m\ 38^s{\cdot}3$ L.S.T. = $7^h\ 43^m\ 40^s{\cdot}1$ L.M.T.

and reappeared at the bright limb at $4^h\ 39^m\ 21^s{\cdot}5$ L.S.T. = $8^h\ 48^m\ 12^s{\cdot}7$ L.M.T.

Power employed 135 on the micrometer.

Saturday, Sept. 7, 1867, Occultation of B. A. C. 6932.

The Star disappeared instantaneously at the Moon's dark limb at $20^h\ 55^m\ 20^s$ L.S.T. = $9^h\ 49^m\ 20^s{\cdot}5$ L.M.T.

The reappearance was not observed.

Power 154.

Sunday, Sept. 8, 1867, Occultation of ρ^2 *Sagittarii.*

The Star disappeared instantaneously at the Moon's dark limb at $20^h\ 57^m\ 18^s{\cdot}6$ L.S.T. = $9^h\ 47^m\ 22^s{\cdot}9$ L.M.T.

The reappearance was not observed, the Moon, as in the last case, having descended behind some trees.

Power 135 on the micrometer.

Note on the Lunar Eclipse of Sept. 13, 1867. By Capt. W. Noble.

I of course observed the Eclipse of the Moon on the night of the 13th of September ult.; but a transcript of my notes would possess very little interest; mainly referring, as they do, to the times of immersion in, and emersion from, the Earth's shadow of the principal craters. Inasmuch, however, as Mr. Browning has stated that he failed to detect any *colour* in the shadow, either when employing a reflector or a refractor, I may just say that in my own 4·2-inch refractor, the shadow presented what an artist would call a warm grey tint; and at the period of the greatest phase, and for some time afterwards, the Moon's limb N. of *Aristarchus* presented a strong copper tinge, which was particularly marked about $12^h\ 42^m$.

Comet III. 1867.

Discovered 27th September by Herr Bäker, at Nauen, and 4 hours later by Dr. Winnecke. The following elements, calculated by Dr. Tietjen from Bonn and Vienna Observations of Oct. 1, and Berlin Observations of Oct. 10 and 17, are given, *Astron. Nach.* No. 1664:—

$$
\begin{aligned}
T &= 1867,\ \text{Nov. } 6{\cdot}99920 \text{ Berlin M.T.} \\
\varpi - \Omega &= 148^\circ\ 36'\ 58''{\cdot}9 \\
\Omega &= 64\ \ 58\ \ 27{\cdot}1 \\
i &= 96\ \ 33\ \ 30{\cdot}5
\end{aligned}
\left.\vphantom{\begin{aligned}a\\b\\c\end{aligned}}\right\}\text{ Mean Equinox } 1867{\cdot}0
$$

$$\log q = 9{\cdot}519074$$

Minor Planet (92) Undina.

Discovered by Dr. C. H. F. Peters, at the Hamilton College Observatory, Clinton, U.S., July 9, 1867. The first observations were as follows:—

1867, July 7 $15^h\ 26^m\ 32^s{\cdot}5$ M.T. $\alpha = 21^h\ 20^m\ 51^s{\cdot}4$ $\delta = -21^\circ\ 31'\ 12''{\cdot}2$

by 10 comparisons with O. Arg. 2138; and the following morning, by 8 comparisons with the same star:—

1867, July 8 $15^h\ 20^m\ 0^s{\cdot}7$ M.T. $\alpha = 21^h\ 20^m\ 25^s{\cdot}94$ $\delta = -21^\circ\ 37'\ 24''{\cdot}2$

The following elements, calculated by Dr. Peters, are given, *Astron. Nach.*, No. 1665:—

Epoch 1867, Jan. 0·0 Berlin M.T.

$$
\begin{aligned}
M &= 304^\circ\ 10'\ 16''{\cdot}2 \\
\varpi &= 334\ \ 29\ \ 30{\cdot}8 \\
\Omega &= 102\ \ 50\ \ 56{\cdot}1 \\
i &= 9\ \ 56\ \ 22{\cdot}0 \\
\phi &= 5\ \ 58\ \ 27{\cdot}5 \\
\mu &= 622''{\cdot}3906 \\
\log a &= 0{\cdot}5039624
\end{aligned}
$$

(ϖ, Ω, i: Mean Equinox, 1867·0)

The magnitude, October 4, being about 11·3.

Minor Planets (93) and (94).

No elements appear to be yet published of these last two Minor Planets discovered by Prof. Watson, Director of the Ann-Arbor Observatory, (93) August 24, and (94) September 6. The two planets were each of the magnitude 11.

ERRATUM.

Memoirs, Vol. XXXV.

In page 25, columns 5 and 6, of the Table, Comparison with Struve's Stars (Place by Chart for 1826) of Star, Struve 409, W. H. IV. 44,

For $3^h\ 31^m \cdot 3 \quad 70^\circ\ 48'$, *read* $3^h\ 21^m + \quad 70^\circ\ 15' \pm$.

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MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

Vol. XXVIII. *December* 13, 1867. No. 2.

Admiral R. H. Manners in the Chair.

The Earl of Rosse, Birr Castle, Ireland;
William Cotterell, Esq.. Walsal; and
David Gill, Esq., Aberdeen,

were balloted for and duly elected Fellows of the Society.

Note on the Total Solar Eclipse of 1868, *August* 17–18. By G. B. Airy, Esq., Astronomer Royal.

It is perhaps deserving of notice that the path of the totally dark shadow in this great eclipse, between Africa and India, coincides through a large portion of its length with the courses of our mail-steamers between Aden and Bombay.

Under the new contract for the mail-conveyance (for early communication of the particulars of which I am indebted to the kindness of the Secretary of the Post Office), a mail-steamer is to leave Aden on August 16, and will be due at Bombay on August 23, and a mail-steamer is to leave Bombay on August 11, due at Aden (including the estimated effect of monsoon) on August 22. Both these steamers will pass through the dark shadow. The steamer from Bombay on August 18 will be starting nearly at the time of totality; but will not then be in the total darkness.

Although the motion of a ship destroys the possibility of making many of the most important of those observation which can be made on shore, yet various observations can be made well.

The red prominences which have been seen with the naked eye can certainly be seen with a good opera-glass, and their appearances and disappearances can be noted. The polarization of the corona can be seen well by a polarizing test which acts by extinction, as the Nicol's prism. Possibly, with a hand-spectroscope and narrow-chink, lines in the spectrum of the corona may be seen. And marine and meteorological phenomena may be noticed, such as have never yet been observed.

Viewing the general ability and intelligence of the Officers of the Peninsular and Oriental Steam Company, and the rank and education of the passengers who may probably be making the voyages, it is not too much to hope that advantage may be taken of this opportunity, such as will never again recur, to observe with care this great phenomenon.

Royal Observatory, Greenwich,
1867, *December* 7.

On the Solar Eclipse, Aug. 1868.
By G. Johnstone Stoney, M.A., F.R.S.

In May last I sent a Memoir to the Royal Society on the constitution of the atmospheres of the Sun and stars, which contained in an Appendix suggestions relative to observations of much interest which might be made during the Eclipse of August 1868, and for which there will not occur so good an opportunity for several years afterwards. An abstract of this communication has been published in the *Proceedings of the Royal Society*, and reprinted in the *Philosophical Magazine*, but the memoir and its appendix are not yet in type. As so great a delay has occurred, I fear lest the suggestions to which I have referred may not appear in time to be of use, and I therefore venture to submit them to the Royal Astronomical Society.

In the memoir it is shown that the gases which constitute the solar atmosphere range to unequal heights, and that the order in which the outer boundaries of those which are known succeed one another is probably the following:—Hydrogen extending furthest; then in order after it sodium and magnesium; calcium; chromium, manganese, iron, cobalt, and nickel; and lastly, copper, zinc, and barium. These, and whatever other gases exist in the Sun's atmosphere, intercept all light coming from beyond them of the refrangibilities which correspond to their spectral rays, and substitute for it the feebler light which emanates from their own upper strata. In this way they produce those dark lines in the spectrum which are so familiar, and the various intensities of which depend in great measure upon the different temperatures of the upper layers of the gases in which they have their origin.

Now if the Corona which is seen during a total eclipse is

caused, as we must presume, by the Sun's enormous outer atmosphere projecting beyond the disk of the Moon, the light which reaches us from it is probably in part borrowed light, and in part due to the atmosphere being itself self-luminous. Borrowed light, however it may originate,* will give a spectrum resembling the Sun's, whereas any light emitted by the Solar atmosphere in virtue of its being incandescent will consist of bright rays in the same positions as some of Fraunhofer's lines. Accordingly, when examined through a spectroscope, adapted to an equatoreal telescope,† much of the light of the Corona may be found to resolve itself into a multitude of bright lines, the brightest being coincident with the faintest of Fraunhofer's lines. If this should prove to be the case, and if the observer could train himself to distinguish in the hurry and under such novel circumstance‡ the lines of the different gases, it would even be possible to ascertain how high in the Sun's atmosphere each reaches, by using a curved slit, and noting the moment at which each set of lines is obliterated by the advancing Moon. This would be a determination of exceeding interest. The observations should commence immediately after the beginning of totality and be kept up to the end of it, as it is only from situations close to the Sun's disk that the brightest lines can come.

Directly outside the photosphere there lies a stratum of the Sun's atmosphere which is still hotter than the photosphere, and on the outer boundary of this hot region there appears to be a shell of excessively faint cloud, part of which is to be seen in Mr. De La Rue's photographs of the Eclipse of 1860. It probably extends the whole way round the Sun. It is therefore very desirable that this faint shell, which seems to lie at a distance of 8 or 10 seconds of space from the edge of the Sun's disk, should be observed, both from a central station and from stations close to the northern and southern limits of totality, so as to ascertain whether, as we have reason to presume, it is continuous round the disk. For this purpose telescopes of moderate power, and any way mounted, would suffice.

It is not likely that there will be many spots, but if any should present themselves upon the edge of the disk within a week of the eclipse they should be observed for some days be-

* Borrowed light may come either from a mist of solid or liquid particles in the Sun's atmosphere, or because some of the gases are sensibly coloured, or from irregular refractions occasioned by the troubled condition of the Sun's atmosphere; but will not in any considerable degree arise from the illumination of the Earth's atmosphere. It is from the absence of this last and chief source of borrowed light that the Corona comes into view, and observations during an eclipse are so precious.

† The equatoreal stand is not essential, as it would be enough to provide a side reflector with a slit in it, through which the rays to be observed in the spectroscope shall pass; and the rest of the image being viewed in the reflector by an assistant, he could by hand movements sufficiently direct the telescope. A telescope of considerable aperture and focal length would be best.

‡ One of the most novel of these circumstances is that the spectrum of each gas will present itself with inverted intensity, the brightest lines obtained by artificial means being in general those which are dimmest in the Corona, and *vice versâ*.

fore and after, with a view to learning whether they are related to ascending clouds in the way pointed out in the memoir. These observations could probably be best made at Kew, but to guard against bad weather, it might be advisable to associate with Kew some other Observatory. Possibly there may be records in existence for instituting this inquiry in regard to the eclipses of 1842, 1851, or 1860. It is perhaps not impossible that the heavy mass of cloud marked $g g^1$ in Mr. De La Rue's diagram of the eclipse of 1860, may have been the source of a cyclone which occasioned the neighbouring group of spots. If so, the cloud must have afterwards drifted a good deal towards the pole (which is the direction in which the probable course of the solar trade wind would have carried it), and also come through the rotation of the Sun into a position in which it was much foreshortened.

Finally, it is evident from the observations of the eclipse of 1860, that flame-like protuberances are formed of various materials. Probably they are most of them very attenuated mists of solid or liquid particles, but it is also possible that there may be some in a gaseous state. It is, in fact, shown in the abovementioned memoir that if two of the gases of the solar atmosphere are kept asunder by the temperatures which prevail in its low-lying strata, but can unite into a compound gas under the diminished temperature and pressure which prevail at greater heights, or *vice versâ*, the gas which in such cases presents itself only at great altitudes, will comport itself, in many respects, like a cloud, and in particular will become intensely heated, and emit the rays which constitute its gaseous spectrum. A similar state of things would result from such a change in the spectrum emitted by a constituent of the Sun's atmosphere, as we know from Plücker's experiments can take place in nitrogen and other gases. It is desirable, therefore, that the spectra of the protuberances should be examined, if this prove practicable, in order to determine whether they all resemble the solar spectrum, as they must if these clouds are all mists, or some of them consist of bright lines, as they will if gaseous. For such observations a telescope whose motions are under the control of an assistant looking in sideways would probably be best. I think, however, that the persons who are willing to devote themselves to such delicate observations would do well to prepare for them by staying for some time beforehand and up to the commencement of totality in the subdued light of a darkened chamber.

Shortly after the time of the solar eclipse the morning zodiacal light will be visible in great splendour to the members of the expedition, and it is very much to be desired that the opportunity should not be lost of obtaining a careful spectral examination of it by experts. This would not require any telescope;*

* That is, provided the collimator is sufficiently long to render the angular aperture of its lens viewed from the slit, not more than the angular breadth

but a binocular spectroscope, consisting of two similar instruments placed parallel to one another, would double the light.*

Some Remarks on the Value of the Solar Parallax, as deduced from the Parallactic Inequality in the Earth's Motion. By E. J. Stone, Esq.

In section 8 of Mr. Newcomb's "Investigation of the Distance of the Sun" will be found a discussion of the value of the Sun's mean equatoreal horizontal parallax given by the parallactic inequality in the theory of the Earth's motion. The coefficient of the parallactic inequality adopted by Mr. Newcomb is $6''\cdot520$, a value but little different from that adopted by Le Verrier in the *Annales de l'Observatoire Impérial de Paris*, Mémoires, tome iv., p. 100. The results obtained by Mons. Le Verrier were, if Π denote the mean horizontal equatoreal solar parallax, μ the mass of the Moon,

$$\mu = \frac{1}{81\cdot84} \quad \Pi = 8''95.$$

In the *Monthly Notices* for 1867, April 12, I pointed out, that a slight error had been made in the deductions of these values, and that the result should have been

$$\Pi = 8''\cdot91 \quad \mu = \frac{1}{81\cdot48}$$

Mr. Newcomb has obtained values widely different both from Mons. Le Verrier's original values and these values as corrected by me.

The values assigned by Mr. Newcomb are as follows:—

$$\Pi = 8''\cdot809 \quad \mu = \frac{1}{81\cdot08}$$

of the zodiacal light at the part of it observed. Otherwise, there will be advantage in placing a lens, which need not be achromatic, in front of each collimator.

* A similar arrangement might be used with a telescope upon all objects which are not stellar—the two spectroscopes being provided with collimators of unequal length and inclined to one another so as to be directed towards two parallel slits brought as close as possible together, and the light being diverted up one of the collimators either by total reflections, as in binocular microscopes, or by a small achromatised prism. In this way the light would be nearly doubled, an effect which could not be produced by an enlargement of the telescope. By moving the achromatised prism the image in one spectroscope could be made to shift laterally, and it is likely that the position of coincidence of the two spectra would be readily seized, even with extremely faint spectra. To secure this motion of the images with the instrument for observing the zodiacal light, the prisms of the spectroscopes might be placed a little out of the position of minimum deviation, and one of them so mounted as to admit of rotation through a small angle.

The discordances between the masses of the Moon and resulting parallaxes are so large that either Mr. Newcomb is in error or Mons. Le Verrier has made a much more important mistake than the trifling numerical one pointed out in my former paper.

I had examined Mons. Le Verrier's work by deducing a value of the Moon's mass before the publication of my short note in April, but I have now again gone through the work. The differences between the results obtained will be found to arise from two distinct causes.

1st, Le Verrier adopts

$$\operatorname{Log} \frac{\Pi^3}{m''} = 8{\cdot}35199.$$

Newcomb adopts

$$\operatorname{Log} \frac{\Pi^3}{m''} = 8{\cdot}35488.$$

2nd, Le Verrier finds for the relation between Π, μ and the adopted coefficient, the equation

$$\Pi = 0{\cdot}016620 \text{ P} \left(1 + \frac{1}{\mu}\right).$$

Newcomb,

$$\Pi = 0{\cdot}016461 \text{ P} \left(1 + \frac{1}{\mu}\right).$$

Neither Le Verrier nor Mr. Newcomb has given the data from which he has deduced his value of $\log \frac{\Pi^3}{m''}$.

I shall however assume the length of the invariable pendulum l beating a mean second on latitude $= \sin^{-1} \frac{1}{\sqrt{3}}$ to be

$$0^{\mathrm{m}}{\cdot}992666 \frac{434{\cdot}86}{433{\cdot}86}. = l\left(1 + \frac{2}{3} m\right)$$

and log (equatoreal semi-diameter of Earth in metres)

$$= 6{\cdot}8046271 = \log \text{R}$$

Logarithm, which must be added to log R to obtain the log (semi-diameter to the parallel $\sin^{-1} \frac{1}{\sqrt{3}}$) $= 9{\cdot}9995166$.

In these data I follow Hansen. The same data appear to me to have been adopted by Mr. Newcomb.

Then if

$$= c\left(1 + \left(\frac{1}{3} - \sin \lambda^2\right) \epsilon\right)$$

be the equation of the Earth's spheroidal surface, fE the Earth's mass, m the ratio of $\frac{\omega^2 c}{\text{mean gravity}}$, we have

$$fE = Gc^2\left(1 + \frac{2}{3}m\right),$$

where G is the gravity on parallel $\sin^{-1}\frac{1}{\sqrt{3}}$. Therefore

$$1 = \pi^2\frac{l}{G} = \pi^2\frac{c^2 l}{fE}\left(1 + \frac{2}{3}m\right). \qquad (1)$$

Now let T be the sidereal year expressed in mean seconds, a the length which satisfies Kepler's third law. Then

$$T^2 = 4\pi^2\frac{a^3}{fS}. \qquad (2) \quad S = \left\{\begin{matrix}\text{Sun's mass} \\ + \text{Earth's mass}\end{matrix}\right\}.$$

Now Le Verrier takes for his unit of length a, and he finds, expressed in this unit, $r =$ mean distance of Sun from Earth $= 1{\cdot}000142 \times a$.

$$\therefore \qquad T^2 = \frac{4\pi^2}{(1{\cdot}000142)^3}\frac{r^3}{fS} \qquad (3)$$

$$\therefore \qquad \frac{S}{E}\cdot\frac{c^3}{r^3} = \frac{4}{T^2}\cdot\frac{1}{(1{\cdot}000142)^3}\,\frac{c}{l\left(1 + \frac{2}{3}m\right)}$$

Now $c = Rp$; where $\log p = 9{\cdot}9995166$.

$$\therefore \qquad \frac{S}{E}\cdot\frac{R^3}{r^3} = \frac{4}{T^2}\cdot\frac{R}{l}\quad\frac{1}{(1{\cdot}000142)^3 p^2\left(1 + \frac{2}{3}m\right)}$$

$$\frac{S}{E}\cdot\Pi^3 = \frac{4}{T^2}\cdot\frac{R}{l\sin^3 1''}\cdot\frac{1}{(1{\cdot}000142)^3 p^2\left(1 + \frac{2}{3}m\right)}$$

$$\text{Log}\,\frac{\Pi^3}{m''} = 8{\cdot}35475$$

Agreeing closely with Mr. Newcomb's value.

From the theory of the motion of the Earth about its centre of gravity we have the following formula:—*Serret, Annales de l'Observatoire de Paris*, tome v.

$$\text{(A)} \qquad \iota = \frac{\text{Mass of Moon}}{\text{Mass of Sun}} \left(\frac{\text{Mean Dist. of Sun}}{\text{Mean Dist. of Moon}}\right)^3$$

$$\text{(1)} \qquad N = [9\cdot38725]\ \kappa\,\iota$$

$$\text{(2)} \qquad P = [9\cdot96272]\ \kappa + [9\cdot95922]\ \kappa\,\iota$$

$$N = 9''\cdot223 \qquad P = 50''\cdot378$$

I adopt the same values of the constants of nutation and luni-solar precession as Mr. Newcomb.

Then

$$\iota = \mu\ \frac{E}{S} \cdot \left(\frac{\frac{R}{r_1}}{\frac{R}{r}}\right)^3$$

$$\iota = \mu\ \frac{E}{S} \cdot \frac{(B\ .\ \sin 1'')^3}{\Pi^3\ .\ (\sin 1'')^3} = \mu \frac{E}{S}\ \frac{B^3}{\Pi^3}$$

where B is the *constant* of lunar parallax.

$$\therefore \quad \iota = \mu\ \frac{B^3}{\frac{\Pi^3}{m''}}$$

From (1) and (2) we find

$$\begin{aligned} \text{Log } \kappa\,\iota &= 1\cdot57762 \\ \text{Log } \kappa &= 1\cdot24018 \\ \text{Log } \iota &= 0\cdot33744 \\ \text{and} \qquad B &= 3422''\cdot707 \end{aligned}$$

These data and the value of log $\frac{\Pi^3}{m''}$, found in the present paper give $\mu = \frac{1}{81\cdot46}$. This value agrees closely with Le Verrier's value.

The expression for the lunar inequality in longitude is

$$\delta l = -\frac{m'}{m + m'}\ \frac{r'}{r}\ \cos s' \sin (l' - l)$$

where m and m' are the masses of the Earth and Moon respectively, r, r', the distances of the Sun and Moon from the Earth; s' the Moon's latitude; l', l, the true longitudes of the Moon and Earth. I shall assume that for r' the true value has been used by Le Verrier. Then, taking constant of lunar parallax $= 3422''\cdot7$, and denoting $\frac{m'}{m}$ by μ, the solar parallax by Π, I find

$$\Pi = 0\cdot016620\ P \left(1 + \frac{1}{\mu}\right)$$

a result agreeing with Le Verrier.

If we adopt Le Verrier's coefficient $6''\cdot50$, we find

$$\Pi = 8''\cdot91$$

I have not incorporated Mr. Newcomb's results with those of Le Verrier's, because Mr. Newcomb has employed the mean longitudes instead of the true. Taking Mr. Newcomb's results separately, we find for the coefficient the numerical value $= 6''\cdot548$. We must now use Mr. Newcomb's equation of condition between Π and P, but I use my own value of $\mu = \frac{1}{81\cdot46}$. I thus find

$$\Pi = 8''\cdot89$$

a result almost identical with that obtained from Le Verrier's coefficient.

The values thus obtained depend, as I stated in my Note of April last, almost entirely on the adopted value of the Moon's mass. The deduction of the value of this quantity, to the required degree of accuracy, from the theory of Precession and Nutation. is a point of considerable difficulty. Mr. Newcomb has applied some corrections for terms of the third order to Serret's results for the equation determining the constant of Nutation, but has used the Precession equation unaltered. I have used Serret's results, neglecting all terms of the third order. If we employed Mr. Newcomb's value of the Moon's mass, we should find

$$\Pi = 8''\cdot87.$$

On Bessel's Mean Refractions. By E. J. Stone.

The refraction-corrections, employed in the reduction of the Greenwich Observations, since 1857, have been computed in the following manner:—

To 82° Z. D. the refractions are those of Bessel's *Tabulæ Regiomontanæ;* from 82° to 85° Z. D. those of the *Tabulæ Regiomontanæ,* with the logarithms of mean refraction diminished by 0·00100; and, finally, from 85° Z. D., the refractions are those of Bessel's *Fundamenta* diminished in the proportion of 1:0·99848. The abrupt changes in passing through 82° and 85° Z. D., can scarcely be considered satisfactory. From the existence of several small, but systematic discordances, I have for some time been convinced, that our refraction-corrections for zenith distances less than 85° are too great. The object of the present paper is to put this in evidence, and to endeavour to determine some more satisfactory method of computing the refraction-corrections.

I have, in the first place, compared the observations of stars above and below the pole, made at Greenwich from the years 1857 to 1865. Let c be the adopted co-latitude; $c + \frac{x}{2}$ the true co-latitude. R, $R_{,}$, the tabular refractions below and above the pole. R $(1 - y)$, $R_{,} (1 - y)$, the true refractions. Δs, Δd, the mean N.P.D. for the beginning of the year, derived from the observations below and above pole, respectively. a, b, the number of observations below and above pole. We then have an equation of condition

$$x + y\,(R \pm R_1) = \Delta s - \Delta d,$$

With a (probable error)² proportional to $\left(\frac{1}{a} + \frac{1}{b}\right)$.

From the observations of the different years I have found for each star the value of $\Delta s - \Delta d$ and have then weighted the several results, roughly, in proportion to $\frac{a\,b}{a + b}$ or w, and thus found mean values of $\Delta s - \Delta d$ with a weight S (w). The factors for y are then computed for the star's zenith distance, with an assumed barometer reading of 30 in., and thermometer 50°. The results of each year have been thus separately treated, in order that the observations, above and below pole, might always have been corrected with the same empirical law of R — D, or law of discordance between reflexion and direct observations. A few observations are, of course, lost by this method of proceeding. I have thought this of little consequence compared with the probable diminution of systematic error. The reflexion observations having been used in determining the co-efficients in the assumed law of R — D have not been further employed in the present paper.

I have next divided the observations into five groups.

1st.	N.P.D.	0°	to 15°
2nd.		15°	to 30°
3rd.		30°	to 37° 40′
4th.		37° 40′	to 43°
5th.		43°	to 46° 29′

In the first group, *Polaris* is observed so frequently, that, if we weighted the observations merely in accordance with the number of observations, the co-latitudes would be made to depend almost entirely upon the observations of *Polaris*, and would thus be affected with any outstanding uncorrected error in the divisions of the circle employed in the observations of *Polaris* and *Polaris* S.P.

It became necessary, therefore, to fix upon some maximum for the weight, calculated in the ordinary way, from the number of observations. Let e be the probable error of an observation of

a star in N.P.D., determined in the ordinary way, by the discordances of the individual observations in a large group from the mean. ι the probable error of the outstanding division errors of the parts of the circle employed in the observations. Then if a, b, a_1, b_1, are the numbers of observations below and above pole of two different stars, and

$$w = \frac{a\,b}{a+b} \qquad\qquad w_1 = \frac{a_1\,b_1}{a_1+b_1}.$$

and W and W_1 are the true weights of the resulting co-latitudes. We have

$$\frac{1}{W} = \left(\frac{1}{a} + \frac{1}{b}\right) e^2 + 2\,\iota^2 = \frac{e^2}{w} + 2\,\iota^2,$$

$$\frac{1}{W_1} = \left(\frac{1}{a_1} + \frac{1}{b_1}\right) e^2 + 2\,\iota^2 = \frac{e^2}{w_1} + 2\,\iota^2,$$

$$\frac{W_1}{W} = \frac{1 + \frac{e^2}{\iota^2}\cdot\frac{1}{2\,w}}{1 + \frac{e^2}{\iota^2}\cdot\frac{1}{2\,w_1}}.$$

For *Polaris* and *Polaris* S.P. we have $e = 0''{\cdot}6$, and ι very nearly $0''{\cdot}2$. If, therefore, we put w indefinitely great

$$\frac{W_1}{W} = \frac{1}{1 + \frac{4{\cdot}5}{w_1}}.$$

and for $w_1 = 20$,

$$\frac{W_1}{W} = \frac{5}{6} \text{ very nearly.}$$

After, therefore, the theoretical weight 20 is reached, very little greater accuracy can be expected, however much the number of observations may be increased.

I have employed 20 as the maximum weight to be assigned to the co-latitude determined from observations of any one star.

The discordances for the five groups are

(1)	$+\,0''{\cdot}240$	weight	130
(2)	$+\,0{\cdot}196$		88
(3)	$+\,0{\cdot}570$		31
(4)	$+\,1{\cdot}054$		54
(5)	$+\,2{\cdot}190$		28

The equations connecting these discordances and the corrections for co-latitude and mean refraction are

$$
\begin{array}{lrrcr}
(6) & 11\,x & +\,1034\,y & = & +\;2''\!\cdot64 \\
(7) & 9\,x & +\,1197\,y & = & +\;1\cdot76 \\
(8) & 6\,x & +\,1272\,y & = & +\;3\cdot42 \\
(9) & 7\,x & +\,2030\,y & = & +\;7\cdot39 \\
(10) & 5\,x & +\,2350\,y & = & +\;10\cdot95
\end{array}
$$

The equations have been multiplied by numbers to make the probable errors of the second members nearly equal. Reducing these equations by the method of least squares, we find the following equations:

$$
\begin{array}{rcrcr}
312\,x & + & 56465\,y & = & 171''\!\cdot88 \\
56465\,x & + & 137633349\,y & = & 49920\cdot92
\end{array}
$$

From which we have

$$x = -\,0''\!\cdot410 \qquad\qquad y = 0\cdot00531$$

The discordances (1), (2), (3), (4), and (5), are reduced as follows:—

1	+ 0″·24	″·15
2	+ 0·20	− 0·10
3	+ 0·57	− 0·14
4	+ 1·05	− 0·08
5	+ 2·19	+ 0·10

The discordances are now reduced to quantities quite within outstanding division errors even over a group.

The result gives for Greenwich

co-latitude 38° 31′ 21″·61.

The value of y indicates that the mean refractions as given by Bessel's *Tabulæ Regiomontanæ* at barometer 30 in., and thermometer 50°, require to be diminished in the proportion of 0·99469 : 1. I have here only considered the case of Z. D. from 0° to 85°.

Now in the *Tabulæ Regiomontanæ* the refractions to 85° Z. D. are those of the *Fundamenta* increased in the proportion of 1·003282 to 1.

If, therefore, we adopted the refractions of Bessel's *Fundamenta* we should only require to diminish the refractions in the proportion of 0·99797 to 1.

For zenith distances below 85° Z. D. the Greenwich Observations are at present reduced with the refractions of the *Fundamenta* diminished in the proportion of 0·99848 : 1.

The refractions thus reduced appear to represent the observa-

tions as closely as can be well expected for such considerable zenith distances.

If, therefore, we adopted for Greenwich the refractions of the *Fundamenta*, with the mean refractions diminished in the proportion of

$$0{\cdot}99797 : 1,$$

we should have all our refractions computed from one set of tables, and representing the observations (in mean results) within, or at least very nearly within, errors of observation.

The publication of the Melbourne Observations for 1863, 1864, and 1865, furnishes a large number of observations in N.P.D. comparable with corresponding observations at Greenwich. I have, therefore, availed myself of the Melbourne Observations to test the accuracy of the proposed diminution of the Greenwich tabular refractions. It has, however, been first necessary to discuss the Melbourne Observations above and below pole in the same manner as the Greenwich Observations, in order to obtain the Melbourne colatitude. The Melbourne refractions have been computed from the *Tabulæ Regiomontanæ*. Proceeding exactly in the same way as for the Greenwich Observations, I have divided the results into five groups.

				Direct — S.P.	Weight.
(1)	N.P.D.	147° to	150°	$+2''{\cdot}480$	11
(2)		150	155	$+1{\cdot}585$	8
(3)		155	160	$+0{\cdot}726$	8
(4)		160	170	$+0{\cdot}738$	26
(5)		170	Pole	$+1{\cdot}007$	122

From these groups I have formed the following five equations with second members nearly equally probable:—

$$
\begin{array}{lrrl}
(6) & 3x & +1446\,y & = +\;7''{\cdot}440 \\
(7) & 3x & +1020\,y & = +\;4{\cdot}755 \\
(8) & 3x & +\;705\,y & = +\;2{\cdot}178 \\
(9) & 5x & +\;870\,y & = +\;3{\cdot}690 \\
(10) & 11x & +1694\,y & = +11{\cdot}077
\end{array}
$$

Solving these equations by the method of least squares, I find

$$x = +\,0''{\cdot}298 \quad . \quad y = 0{\cdot}00372$$

The discordances (1), (2), (3), (4), (5), are reduced as follows:—

1	$+2''{\cdot}48$	to	$+0''{\cdot}39$
2	$+1{\cdot}59$		$+0{\cdot}03$
3	$+0{\cdot}73$		$-0{\cdot}44$
4	$+0{\cdot}74$		$-0{\cdot}20$
5	$+1{\cdot}01$		$+0{\cdot}23$

There are many very abrupt changes in the corrections applied for division error to the Melbourne Circle, and some considerable uncertainty must exist from this cause in the results. I believe the above discordances are not much greater than may be expected.

Finally, I have compared the Greenwich and Melbourne Observations in N.P.D. I have employed for this purpose the results of the Greenwich seven-year Catalogue, and have brought up all the observations to the year 1864 for comparison with the Melbourne results. I have then divided the corresponding observations into eleven groups.

			Green. N.P.D. — Melb. N.P.D.	Weight.
1	N.P.D. 45° 12′		+ 3″·04	9
2	50° to	55°	+ 1·71	21
3	55	60	+ 0·87	25
4	60	70	+ 1·35	100
5	70	80	+ 1·52	121
6	80	90	+ 0·99	138
7	90	100	+ 0·62	82
8	100	110	+ 0·86	78
9	110	115	+ 0·83	53
10	115	120	+ 0·72	56
11	120°		+ 1·30	16

Assuming that the true refraction

$$\text{For Greenwich} = \text{Tab.}\,(1 - x)$$
$$\text{For Melbourne} = \text{Tab.}\,(1 - y)$$

and that the relative correction for errors in latitude is δc, we have the following equations with nearly equally probable second members:—

1	$21\,x$	$+ 1245\,y$	$= + 9''{\cdot}12$	$+ 3$	δc
2	$65\,x$	$+ 1180\,y$	$= + 8{\cdot}55$	$+ 5$	δc
3	$105\,x$	$+ 785\,y$	$= + 4{\cdot}35$	$+ 5$	δc
4	$270\,x$	$+ 1200\,y$	$= + 13{\cdot}50$	$+ 10$	δc
5	$484\,x$	$+ 825\,y$	$= + 16{\cdot}72$	$+ 11$	δc
6	$720\,x$	$+ 660\,y$	$= + 11{\cdot}88$	$+ 12$	δc
7	$783\,x$	$+ 342\,y$	$= + 5{\cdot}58$	$+ 9$	δc
8	$1260\,x$	$+ 207\,y$	$= + 7{\cdot}74$	$+ 9$	δc
9	$1428\,x$	$+ 112\,y$	$= + 5{\cdot}81$	$+ 7$	δc
10	$1995\,x$	$+ 77\,y$	$= + 5{\cdot}04$	$+ 7$	δc
11	$1520\,x$	$+ 32\,y$	$= + 5{\cdot}20$	$+ 4$	δc

From which we obtain the following equations for the determination of x and y:—

$$11371545\,x + 2274567\,y = 61872{\cdot}12 + 66005\,\delta c$$
$$2274567\,x + 6294185\,y = 67408{\cdot}69 + 48947\,\delta c$$

$$x = +0{\cdot}003556 + 0{\cdot}00458\,\delta c$$
$$y = +0{\cdot}009424 + 0{\cdot}00612\,\delta c$$

or putting $\delta c = -0{\cdot}056$,

$$x = +0{\cdot}0033$$
$$y = +0{\cdot}0091$$

The errors Green. N.P.D. — Melb. N.P.D. are then reduced as follows:—

				Weight.
(1)	$+3''{\cdot}04$	to	$-0''{\cdot}76$	9
(2)	$+1{\cdot}71$		$-0{\cdot}48$	21
(3)	$+0{\cdot}87$		$-0{\cdot}63$	25
(4)	$+1{\cdot}35$		$+0{\cdot}16$	100
(5)	$+1{\cdot}52$		$+0{\cdot}69$	121
(6)	$+0{\cdot}99$		$+0{\cdot}29$	138
(7)	$+0{\cdot}62$		$-0{\cdot}02$	82
(8)	$+0{\cdot}86$		$+0{\cdot}18$	78
(9)	$+0{\cdot}83$		$0{\cdot}00$	53
(10)	$+0{\cdot}72$		$-0{\cdot}33$	56
(11)	$+1{\cdot}30$		$-0{\cdot}04$	16

The first residual (1) depends upon the observations of only one star. If we rejected the equation arising from (1), the values of x and y would not be greatly modified. The discordances are here larger than could be wished, but, except for the first, I doubt whether they are greatly in excess of uncertainties connected with division errors.

The value of x shows that the refractions of Bessel's *Tabulæ Regiomontanæ* require to be diminished considerably in order to represent the Greenwich Observations. So far as the comparison with the Melbourne Observations is concerned, the refractions of the *Fundamenta* would almost do for Greenwich without any correction. I believe, however, that the result obtained from the Greenwich Observations, above and below pole, is entitled to most weight. The correction thus deduced for the Melbourne refractions is exceedingly great, viz. $y = 0{\cdot}00914$, whilst, from a comparison of the Melbourne Observations above and below pole, I obtained only a correction of

$$y = 0{\cdot}00372.$$

The discordance between these results is so great, that if we introduced one of the values into the equations from which the

other has been deduced, the residual errors would be much greater than any existing uncertainties connected either with observations or outstanding errors of division. At least this is my own opinion on the point. I am, therefore, inclined to look upon the difference as real, not perhaps to the full amount of the discordance, but to a considerable amount, and to attribute it to a real difference in mean refraction towards the south and north at Melbourne, the refractions towards the south being greater because of the moisture present in the air, the refractions towards the north being considerably less because the chief effective strata of air have been to a considerable extent deprived of moisture.

14th November, Meteor Epoch 1867. By E. J. Lowe, Esq.

Nov. 12. Foggy and densely overcast all evening and night.

Nov. 13. Foggy and overcast, with E.N.E. wind, till $7^h\ 40^m$ P.M., when the sky suddenly became cloudless and the wind changed to S.E., from this time till $9^h\ 10^m$ P.M. no clouds and no meteors. At $9^h\ 10^m$ P.M. few cumuli; $9^h\ 30^m$ P.M. overcast with cumuli in S. current.

Nov. 14. $1^h\ 10^m$ A.M. again clear, except few high thin cirri. Wind S. Lunar halo faint, and a yellow glare on N. horizon extending to altitude 15°.

$1^h\ 27^m\ 30^s$ A.M. a colourless meteor, = ✱ 2 mag., shot rapidly from near λ to β *Ursæ Majoris*.

2 A.M. high thin cumuli in S., current moving rapidly.

2 A.M. till 3 A.M. ibid. No meteors.

$3^h\ 10^m$ A.M. sky covered with rapidly-flying thin cumuli in S.E. current, above which others in S. current. Slight breeze and no fog.

$3^h\ 55^m$ A.M. overcast, Moon's place visible.

$5^h\ 15^m$ A.M. ibid., wind N.E., clouds rapid from S.E.

$5^h\ 50^m$ A.M. quite overcast, hazy wind N.E.; sky lighter to E. of zenith than elsewhere.

$7^h\ 40^m$ A.M. ibid., fog coming on.

From 9 A.M. fog with incessant rain till 7 P.M., then fair; fog cleared off, but overcast.

15th. Overcast.

Highfield House,
1867, *Nov.* 19.

The Meteors of November 13–14, 1867, *observed at Bloomington, Indiana.* By Prof. Daniel Kirkwood, L.L.D.

During the night of November 13th, Prof T. A. Wylie, D.D., and myself, assisted by several students, kept watch for meteors from $9^h\ 15^m$ P.M. to $5^h\ 15^m$ A.M., at the Indiana University, Bloomington, Indiana. The night was very unfavourable for observations, the sky being obscured by so dense a haze that scarcely any fixed stars, except those of the first magnitude, were at all visible. Hence none but the largest meteors and such as appeared near the zenith could be detected. The results obtained were as follows:—

	from h m	to h m		
November 13th,	9 15	12 0*	1	meteor.
14th,	0 0	3 15	75	meteors.
	3 15	4 15	351	,,
	4 15	5 15	98	,,
		Total	525	meteors.

It will be noticed that 351, or two-thirds of the whole number seen in eight hours, were observed between $3^h\ 15^m$ and $4^h\ 15^m$. The maximum occurred about $3^h\ 45^m$, when the rate was twelve per minute. All the meteors, with one or two exceptions, were "conformable." Two or three were sometimes seen simultaneously, and a tendency to appear in clusters was distinctly noticed. A very remarkable meteor was observed in *Leo*, a little above the *Sickle*, about $3^h\ 40^m$. It was *stationary*, and continued visible between two or three seconds. It was at first small, but increased rapidly in magnitude until, just before extinction, it surpassed *Regulus*, the only star in the *Sickle* then visible through the haze. This meteor was undoubtedly near the radiant. On account, however, of the cloudy state of the atmosphere no effort was made to locate the common point of divergence.

Bloomington, Indiana,
November 14th, 1867.

An Attempt to facilitate the Prediction of Occultations and Eclipses, and the Approximate Reduction of the observed Phenomenon. By F. C. Penrose, Esq. (Abstract.)

As regards occultations; an occultation (disappearance or reappearance) takes place when the surface of the Earth (considered in the memoir as a spheroid of revolution) intersects the cylinder generated by the rays of light proceeding from the star and touching the Moon's circumference.

* Cincinnati time.

The author submits two methods of solution, part of the process being in each of them geometrical, or, more properly speaking, graphical, conducted by means of an orthographic projection of the occurrence, as seen from the direction of the star: he thinks that the methods are capable of sufficient accuracy for many purposes, and have the advantage that the object of every step is readily seen by the operator, and also of being more expeditious than the methods depending solely on calculation.

The first method, worked with the help of Chart No. I., is intended for prediction only, and may be expected to occupy a few minutes only in the operation, and to furnish an approximate result with an error not exceeding two minutes of time in ordinary cases.

The second method worked by Chart No. II., and which depends to a less degree on geometrical work, ought to give a result true within two minutes of longitude, or eight seconds, or say half a second of the Moon's R.A., except in cases where the star impinges on the Moon's limb at an acute angle, or, in other words, when the observer is at a considerable distance from the central line of occultation, when the error will probably be greater; and such cases should not be relied upon for the determination of longitude unless both the disappearance and reappearance can be observed.

The representation of an eclipse, treated in an analogous way to the occultation, is that of a *perspective* projection on a plane perpendicular to the line of conjunction, and with the Sun at conjunction as the point of view, and at the Moon's distance from the Sun, instead of the *orthographic* projection which represented the occultation.

On the Influence of Aperture in Diminishing the Intensity of the Colour of Stars. By John Browning, Esq., F.R.A.S.

At the last Meeting of the Society some remarks were made on the subject of the amount of colour visible on the Moon during the late lunar eclipse.

I had previously stated that I had failed to detect either the coppery or the blue tints generally seen during the occurrence of this phenomenon. As my observation did not agree with those of several well-known observers, I have given the matter some attention, and endeavoured to ascertain from what cause the discrepancy proceeded.

Mr. Slack suggested that probably my having used a telescope of larger diameter than those employed by most of the observers would prove the explanation desired, and since then I have heard that our able Secretary, Mr. Huggins, is of the same opinion. The result of my inquiries completely confirms this suggestion. I find

that while most observers who use telescopes of only three or four inches aperture speak of the colour as being less than usual, yet very noticeable, observers who use telescopes of seven or eight inches aperture saw very little colour. Neither Mr. Barnes nor myself, observing with a 10¼-aperture, nor Mr. With or his nephew, employing a 12¼-inch silvered-glass speculum, could detect any colour at all.

It is true that I failed equally in detecting colour with a 4-inch object-glass, but I account for this by supposing that the sensitiveness of my eye to faint-coloured light had been injured by the glare of the Moon in the large aperture. Experimenting in connexion with this subject, I have noticed that the chocolate colour of the so-called belts of *Jupiter* is much more perceptible with 6-inches aperture than with 12-inches. Again, a small star in the cluster in *Perseus* appears of an indigo-blue with 8½-inches, prussian-blue with 10¼-inches, and royal-blue with 12¼-inches of aperture. It follows from this that colours estimated by comparison with the ingenious chromatic scale of Admiral Smyth, in which each colour is represented of four different degrees of intensity, will not possess any relative value unless taken in connexion with the aperture employed when the colour was estimated. Were due allowance made for this disturbing influence of variation of aperture, I think many discrepancies between the colours attributed to double stars by different observers might probably be reconciled.

Note.—An enlarged diagram of Smyth's chromatic scale, and another showing the apparent difference in the colour of a star when seen with apertures of 4 inches and 12 inches, was exhibited and described at the time the paper was read.

Minor Planet (93).

The following elements, calculated by Herr Lehrmann from observations of Aug. 25, Oct. 2, and Nov. 4, are given *Astron. Nach.* No. 1669:—

Epoch, 1867, Oct. 2·0, Berlin M.T.

M	=	$66^\circ\ 47'\ 48''\cdot8$	
π	=	$276\ 39\ 54\cdot8$	Mean Equinox, 1867·0.
Ω	=	$5\ \ 2\ 28\cdot0$	
i	=	$8\ 35\ 34\cdot9$	
ϕ	=	$7\ 39\ 29\cdot5$	
μ	=	$776''\cdot43667$	
$\log a$	=	$0\cdot439934$	

ERRATUM IN LAST NOTICE.

Page 1, in the list of persons elected, *for* Alnwrah Road, *read* Almorah Road.

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Printed by Strangeways and Walden, Castle St. Leicester Sq. and Published at the Apartments of the Society, Jan. 9, 1868.

// MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

Vol. XXVIII. *January* 10, 1868. No. 3.

Rev. Charles Pritchard, M.A., F.R.S., in the Chair.

George Parker Bidder, Esq., Paper Buildings, Temple;
Capt. Drayson, R.A., Military Academy, Woolwich;
R. P. Greg, Esq., Prestwich, Manchester;
R. J. Lecky, Esq., Stock Orchard Villas, Caledonian Road;
John Sorley, Esq., LL.D., Principal of the College, Birkenhead;
Thos. Hunter Maule, Esq., LL.D., Vice-Principal of Birkenhead College; and
The Rev. Wm. Owen Williams, Pwleheli, Carnarvonshire.

were balloted for and duly elected Fellows of the Society.

Rotation of Mars. By Richard A. Proctor, B.A.

A series of clearly marked views of *Mars*, taken by Mr. Browning in January and February, 1867, afforded me the opportunity of estimating the rotation of *Mars* by means of an interval of nearly 201 years. In doing this I detected some slight errors in my former calculation. First, the construction of a chart of the orbits of the four inner planets enabled me to form a more accurate estimate of the difference in the geocentric longitude of *Mars* on April 24th, 1856, and on November 26th, 1864, as compared with his geocentric longitude on March 13th, 1666; secondly, the preparation of a chart of *Mars* suggested alterations in the corrections for phase; and, lastly, I found that

I had unaccountably dropped a day in taking the interval of 198 years. The effect of the last error is less important than might be supposed at first sight, since on adding twenty-four hours to the interval, we have to add one rotation of *Mars* to the number taking place in the interval, and it is the difference between one rotation of *Mars* and twenty-four hours (*i.e.* about $37\frac{1}{3}$ minutes only) which has to be distributed amongst upwards of 70,000 rotations.

I now present in a table the results of the calculation of three long periods, viz. from March 12th, 1666, $12^h\ 20^m$ (astronomical time and New Style) to

April 24th, 1856	.. ..	(i)
Nov. 26th, 1864	.. ..	(ii)
Feb. 23rd, 1867	.. ..	(iii)

Int.	Interval in secs.	Cor. for Geoc. Long.	Cor. for Phase.	Corrected Int. in seconds.	No. of Rotations.	Resulting Rotation Period.
(i)	5999524200	0°	− 12°	5999521246	67682	88642·737
(ii)	6270650760	− 248	0	6270589696	70740	88642·734
(iii)	6341394300	− 273	+ 3	6341326590	71538	88642·734

Here the results have been brought into close agreement by selecting suitable values for the phase-corrections. That these values are not far from the truth will be seen by the accompanying tracings of the views in question (see Plate); the arc from cross-line to cross-line along the equator of *Mars* being, of course, 30°.

The corrections for geocentric longitude may be depended upon as being within 1° of the truth. In the accompanying copy of my plate of the orbits of *Mars*, the Earth, *Mercury*, and *Venus*, the positions of *Mars* and the Earth at the several epochs are indicated and connected by straight lines. In determining the approximate position of the Earth at any date several circumstances have to be considered. Thus take the opposition of *Mars* in March, 1666. I find that this took place at midnight (nearly) on March 18th. But it will be seen that the opposition line is placed about one quarter of a degree in advance of the position given to the Earth on March 21. The explanation of this will illustrate the process applied to each epoch:—

My chart shows the position of the Earth from day to day on the supposition that at noon on the 21st December the Earth is at the winter solstice. Now, nearly enough for our purpose, this was the case in leap-year in the beginning of the seventeenth century. But the Earth was about 45′ in advance of the winter solstice at noon on December 21st in leap-years *at the end* of the seventeenth century,—therefore, in 1664, about 30′ in advance. Again, in each common year the Earth loses 15′, so that in 1666 there was at any hour of any day, after February 28, a loss of

Hooke, Mar. 12, 1666, 12h 20m. Dawes, Apr. 21, 1856, 10h 30m. Dawes, Nov. 26, 1864, 11h 46m. Browning, Feb. 23, 1867, 6h 25m.

about 30′ from the position held by the Earth at the same day and hour in 1664. Therefore the position of the Earth at midnight, March 18th, 1666, was about that which would correspond to that date as the chart stands; that is, about two days and a half's motion (or nearly $2\frac{1}{2}°$) behind the point marked March 21st. But owing to the precession of the equinoxes the lines ♋ ♑, and ♎ ♈ in my chart must be shifted about $2\frac{3}{4}°$ forwards around their point of intersection to indicate the position they had in 1666. The difference $\frac{1}{4}°$ indicates the amount by which the opposition-line in question is in advance of the position given to the Earth on March 21st in my chart.

The close agreement between the results obtained,—and that without any noteworthy *forcing* of the correction for phase, *the only doubtful point in the whole question*, induces me to look on the value

$$88642{\cdot}735 \text{ sec. or } 24^h\ 37^m\ 22{\cdot}735^s.$$

as very near the true value of *Mars*' rotation period.

Inductive Proof of the Moon's Insolation.
By J. Park Harrison, M.A.

1. On the assumption that the Moon's substance has a capacity for heat, the mean maximum state of insolation of any hemisphere would evidently be attained at the period of the lunation when the largest surface has been continuously exposed to the Sun *for the longest duration of time.* This occurs at the third or last quarter, when the half-moon then illuminated has been subjected to the solar radiation for a mean period of 265·5 hours $\left(\frac{177 \text{ hrs.} + 354 \text{ hrs.}}{2} = 265{\cdot}5 \text{ hrs.}\right)$, and the remaining half, now in shade, has very recently received the Sun's rays for a period of equal duration.

The epochs of maximum and minimum heat are clearly shown on a horizontal section of the Moon in the diagram (fig. 1), where the light and dark crescents represent her state of insolation in proportion to the number of days during which the Moon's surface has been exposed to or withdrawn from the Sun.*

2. Now the heat which is acquired by the Moon,† and radiated to the Earth, is entirely dark heat; and this, as Prof. Tyndall has pointed out, "would be almost wholly absorbed by our

* The plus signs before the figures in this diagram (+ 1 to + 15) indicate the number of days of sunshine. The minus signs indicate the number of days of shade. In fig. 2 the dark tint A represents heat; the lighter tint B, cold.

† The German physicist Herr Althaus has estimated the heat of the Moon on the 22nd day of the lunation by an elaborate process at several hundred degrees of Fahrenheit. *Pogg. Ann.* 90, p. 551.

atmospheric vapour."* It would consequently tend to raise the temperature of the air above the clouds, and cause increased evaporation from their surface. Cloud would therefore be diminished in density and raised to a higher elevation, and under favourable circumstances it would be dispersed;† in either of which events a sensible fall would necessarily be caused in the temperature of the air near the ground, owing to increased radiation of terrestrial heat to the sky. And precisely opposite results would occur at the period of minimum heat in the Moon.

If our ordinary thermometers, then, give no indication of any changes of temperature at these seasons, it would show either that the Moon is *not* heated by the Sun, or that her state of insolation is insufficient to produce the physical effects which would otherwise have followed.

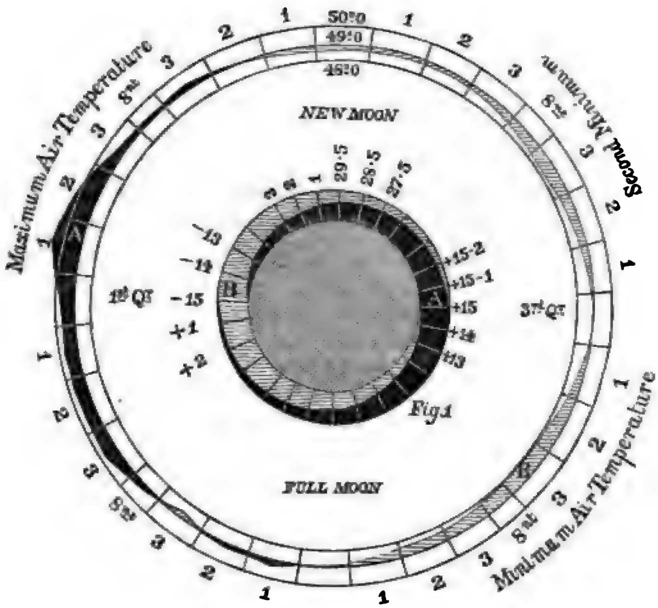


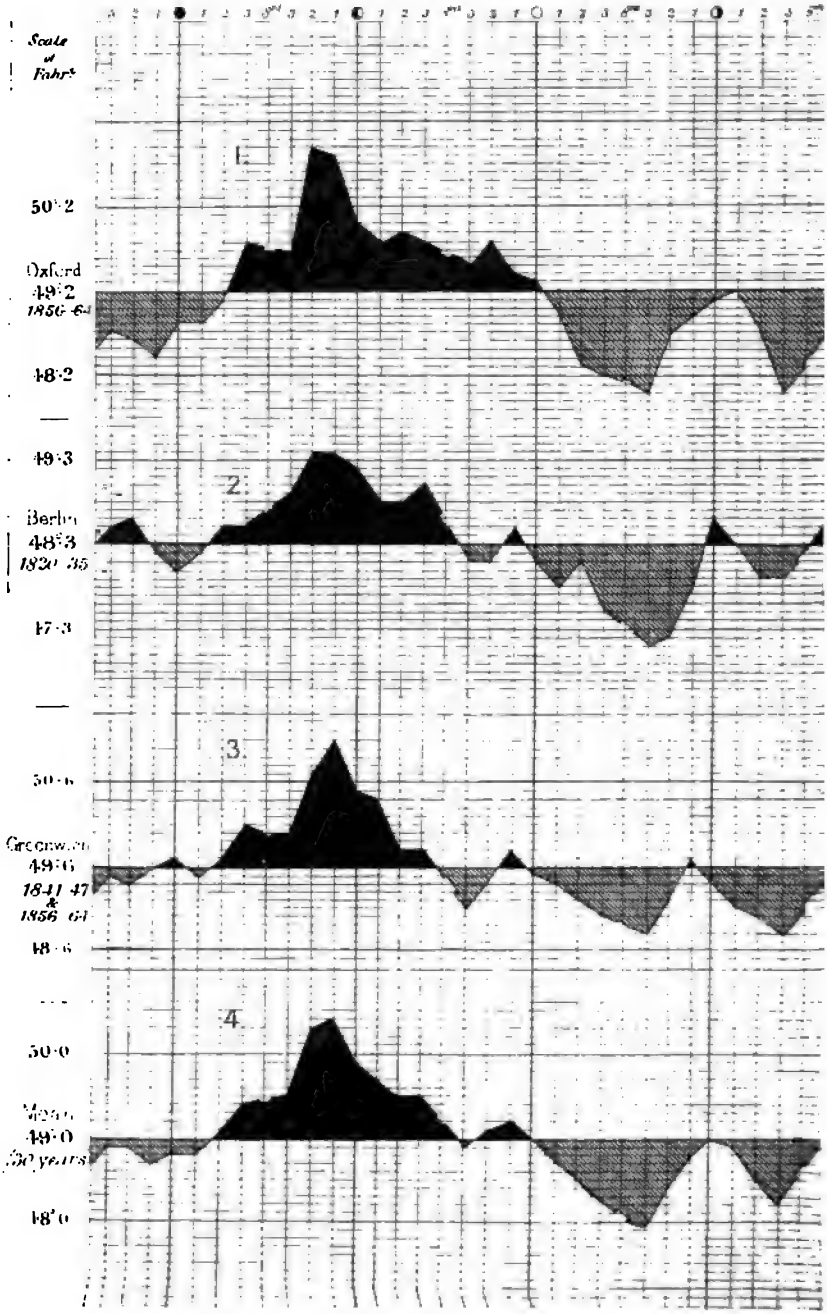
Fig.2

3. The daily mean temperatures, however, at the Observatories of Oxford, Berlin, and Greenwich, when arranged in tables according to the age of the Moon, show conclusively that the temperature of the air near the surface of the ground is very sensibly affected; the maximum mean temperature occurring on

* *Heat*, &c., p. 147. See also Herschel's *Outlines of Astronomy*, 432, p. 261.

† Herschel's *Lectures on Scientific Subjects*, 1866, p. 149.

Curves of Mean Temperature at Oxford, Berlin & Greenwich according to the age of the Moon



J. Basire sc.

Note. The number of Octant days is about half of the others

the average, at each of the three stations, upon the 6th and 7th day of the lunation, when the Moon's crust turned towards the Earth is coldest; and the minimum mean temperature some time after full Moon, when the same crust has been exposed for several days to intense radiation from the Sun.*

This will be seen in the diagram (fig. 2), where a curve of the mean temperatures for each day of the lunation, described about the section of the Moon already referred to, shows the contemporaneous conditions of air-temperature and lunar insolation. The curve itself is derived from the mean results at the three Observatories.

In the curves formed from these means, the dark tint indicates a mean temperature above the average, whilst the lighter tint indicates a mean temperature below the average. It will not escape notice that they coincide in a very remarkable manner (see Plate of Curves).

The Berlin mean temperatures, which were tabulated by Dr. Mädler thirty years ago, were derived from observations taken at 5 A.M and 2 P.M. from 1820 to 1835. The difference between the maximum at first quarter and the minimum near the last quarter is $2^{\circ}\cdot 3$ Fahr.†

At Oxford the daily means were obtained from twelve readings of traces of the self-registering Thermograph, with a few interpolations. The difference between the maximum and minimum mean temperatures is $2^{\circ}\cdot 8$ Fahr.

The Greenwich means were derived from the 2-hourly observations of 1841–47; excepting the means on Sundays and holidays, which are simply arithmetical means of the self-registering maximum and minimum thermometer. From 1856 to 1864 inclusive they were derived from the ordinary daily observations corrected by a small quantity and checked by an examination of the photographic curves. The difference between the maximum and minimum results is $2^{\circ}\cdot 3$ Fahr.

The mean difference in the value of the results at the three Observatories is $2^{\circ}\cdot 5$ Fahr.

4. It will be noticed in the diagram (fig. 2) and also in each curve (see Plate), that, whilst there is but one period of maximum air temperature, two minima occur at nearly equal distances on either side of the Moon's third quarter. They are separated by a marked rise in the curve at the time the greatest heat is assumed to be attained by the Moon, and consequently the lowest mean temperature of the air might have been looked for.

This apparent exception to the physical law above indicated seems to afford additional proof that the general results are due to

* For method of tabulation see *Proceedings of the Royal Society*, May 1865, p. 224.

† On ascertaining the occurrence of the maximum air-temperature on the 6th day after new Moon, Dr. Mädler seems to have put the figures aside for confirmation. He has not since then, that I am aware of, made any use of them; or suggested any explanation of the results.—See *Der Mond*, p. 164.

the causes to which they have been assigned—*fresh cloud having been found to arise a day or two before the third quarter** to supply, as it would seem, the increased demand† for vapour at that period. And the moment when this periodic cloud is dispersed or raised by the agency of the Moon's heat is signalized by the rapid fall in temperature which occurs immediately afterwards. Possibly, however, some part of the lunar radiant heat may reach the surface of the Earth at the time of the Moon's maximum insolation, and so assist in raising the temperature of the air, and in producing increased evaporation.‡

No rise or fall in air-temperature of any amount occurs at new or full moon, though a tendency towards change seems clearly indicated shortly before full moon.§

The maximum effects, then, synchronising so nearly with the epochs of maximum and minimum exposure of the Moon's surface to solar radiation, seem to prove that our satellite is heated by the Sun.

5. The relation which has been thus traced between the Moon's heat and the daily variations of mean temperature, whilst it confirms the world-wide belief in lunar influence, reduces it to its real importance and frees it from the haze which has so long surrounded it. The effects produced would necessarily vary with the amount of cloud and vapour which from time to time happens to be present in the air; and this does not primarily depend upon the Moon.

Ewhurst, Dec. 24, 1867.

A Determination of the Moon's Mass. By E. J. Stone, Esq.

In a Note "On the Value of the Solar Parallax as deduced from the Parallactic inequality in the Earth's motion," printed in the last number of the *Monthly Notices*, I have deduced the value of the Moon's mass from the equations as given by Serret without the modifications introduced by Professor Newcomb. I have since determined these equations independently, retaining all terms of the third order in the Lunar Theory. My results do

* I found this to be the case on tabulating the mean amount of cloud and contemporaneous air-temperature at Greenwich in 1841-47. Both cloud and temperature were found to rise above the average on the three days preceding third quarter. And this was not caused, as I ascertained, by any change in the direction of the wind.

† See Hopkins' *Atmospheric Changes*, p. 333.

‡ See *Annuaire du Bureau des Longitudes*, where Schübler and others are quoted as having found the minimum of cloud to occur after third quarter. *Ann.* 1833, p. 61.

§ Herschel's *Lectures on Scientific Subjects*, p. 149.

not agree with those obtained by Professor Newcomb. As the deduction of the Moon's mass from the theories of Precession and Nutation is a point of real importance, I print my results.

I take γ to denote Delaunay's constant, which, in the first approximation, is equal to the sine $\frac{1}{2}$ (inclination of lunar orbit); a, a_1 the *mean* distances of the Moon and Sun; e, e_1 the excentricities of the lunar and solar orbits; κ a constant depending on the Sun's mean disturbing force, the moments of inertia of the Earth, and the Earth's angular velocity; μ, the motion of the Moon's node, relatively to the line of equinoxes, in a Julian year;

$$\iota = \frac{\text{Moon's Mass}}{\text{Sun's Mass}} \cdot \frac{a_1^3}{a^3};$$

I then find

$$\text{Luni-Solar Precession} = \kappa \left[1 + \frac{3e_1^2}{2}\right] + \kappa\iota \left[1 + \frac{3e^2}{2} - 6\gamma^2\right],$$

$$\text{Constant of Nutation} = \kappa\iota \frac{2\gamma}{\mu}\left(1 + \frac{3e^2}{2} - \frac{5\gamma^2}{2}\right).$$

From which formula I find, with Luni-Solar Precession $= 50''\cdot378$ and Nutation $= 9''\cdot223$.

$$\frac{\text{Moon's Mass}}{\text{Earth's Mass}} = \frac{1}{81\cdot36}.$$

It appears to me that Serret's formulæ are not accurate to the third order. His c would no longer be a constant.

Jupiter and his Satellites. By Thomas Barneby, Esq.

Having had a clear view of the phenomenon on the 21st August last, soon after its commencement, and during the progress which I witnessed, I trust my observation may be recorded.

I used the whole aperture of my 9-inch Equatoreal, made by Mr. Cooke for the late Captain Jacob.

When I first saw the planet, the shadow of the *third* satellite only was on its disk. The *third* satellite itself next made its ingress, and I afterwards saw the several ingresses of the shadows of the *fourth* and *first* satellites, and of such satellites.

The *second* satellite had then become eclipsed, leaving no satellite visible, except on the face of the planet.

The three shadows were perfectly black, and there was no perceptible penumbra, although the outlines were not so clearly defined as I have seen them with a smaller instrument.

The three satellites, when on the disk, were of different colours, the *first* was the lightest and brightest, resembling most its colour when off the disk, and the *fourth* was as black as its shadow.

The *third* satellite was generally of a cinnamon colour, but on its south-western side there was a large double spot of a much darker cinnamon or sponge colour. These markings were very peculiar, and are well delineated in Mr. Dawes's paper in the *Monthly Notices* of November last. I have before described them, as on the apparent east side, which accords with the south-western side, allowing for inversion and the position of the planet.

The belts in the neighbourhood of the equatorial regions of the planet were illuminated with a brilliant rose-coloured tint, which added much to the beauty of the view, and reminded me forcibly of a terrestrial "Evening-red" of more than ordinary magnificence.

South Villa Observatory, Worcester,
16th December, 1867.

Results of the Observations on Sun-spots made in Kew and in Dessau during the Year 1867. Communicated by Messrs. De La Rue, Stewart, and Loewy.

	Kew.				Dessau.			
Months.	No. of new Groups.	Numbers.	Days of Obs.	Days without Spots.	No. of new Groups.	Numbers.	Days of Obs.	Days without Spots.
January	0	..	6	6	0	..	23	23
February	0	..	10	10	0	..	26	26
March	3	770 to 772	10	6	3	1 to 3	26	15
April	2	773 to 774	15	9	1	4	24	16
May	1	775	13	9	2	5 to 6	26	16
June	0	..	13	11	1	7	30	23
July	2	776 to 777	19	14	2	8 to 9	31	18
August	0	..	0	..	3	10 to 12	31	20
September	1	778	8	0	1	13	30	17
October	3	779 to 781	11	3	3	14 to 16	28	13
November	2	782 to 783	10	3	4	17 to 20	22	5
December	3	784 to 786	5	1 (?)	5	21 to 25	15	3
Total	17	770 to 786	120	72	25	1 to 25	312	195

Remarks.—The numbers in the Kew list form a continuation of the Catalogue of Groups, published in the first series of "Re-

searches in Solar Physics," by Warren De La Rue, Balfour Stewart, and Benjamin Loewy, pp. 6–8.

Those days on which it is doubtful whether spots were on the Sun or not, have the sign (?) after them.

Necessary repairs and alterations in the Kew dome caused an interruption in the regular work of the Photoheliograph from August 9th to September 9th.

Although the number of groups observed is the lowest since the commencement of regular Sun observations in 1825, still there were among the number several of very considerable size (March 31, April 5 and 6, and September 9–21). Large solitary spots made their appearance towards the end of the year.

Hofrath Schwabe reports that the uniform brightness of the Sun's surface observable, is the beginning of the year, and the almost total absence of faculæ, both of which phenomena were some time ago submitted to the attention of the Fellows of the Royal Astronomical Society, have disappeared, and that since October the luminosity has again diminished near the edge.

On November 12th, 2^h P.M. (Dessau M.T.), during a very short glimpse of sunlight, he observed near the limb two or three luminous bodies of a cloudlike, fleecy appearance, quite similar to those which he has observed in former years; unfortunately he had no time to study them more closely.

Note on the Variable Star, T *Serpentis*.

1860, $\alpha = 18^h\ 21^m\ 59^s$; $\delta = +6^\circ\ 12'{\cdot}7$. By J. Baxendell, Esq.

This Variable was discovered at Mr. Worthington's Observatory, Crumpsall, in July, 1860, as an outlier of the fine Cluster, No. 72 of Sir William Herschel's 8th class, and a brief account of it was inserted in the *Monthly Notices* for January, 1861; but as it appears not to have been seen since by other observers, and may therefore be supposed to have been merely a temporary star, I have thought it desirable to communicate to the Society the results of all the observations I have hitherto made.

Observed maxima of T *Serpentis*:—

1861	May 12	10·5 mag.
1862	April 17	10·7
1863	April 1	11·0
1866	Dec. 10	11·0
1867	Nov. 25	10·3

Equating, and treating by the method of least squares, we have

Epoch = 1864, Feb. 29.

Mean period = 340·5 days.

Calculating the times of maximum from these elements, we have the following differences between the calculated and the observed times:—

C − O
in days
+ 1·5
+ 2·0
− 6·5
+ 6·5
− 3·0

The greatest difference being only *one fifty-second* of the mean period, it appears that T *Serpentis* belongs to the list of moderately regular periodical variables. When at minimum it is below the 14th magnitude. Its next maximum is due 1868, October 27·5, at which time it will be favourably situated for observation.

Cheetham Hill, Manchester.
January 8, 1868.

On the Maximum of U *Geminorum.* By G. Knott, Esq.

I beg to offer to the Society the following observations of the maximum of Mr. Hind's curious variable star U *Geminorum*, which occurred in December last. The observations were made with my 7⅓-inch Alvan Clark refractor, the magnitude of the variable on each occasion being deduced from a careful comparison with a selected list of neighbouring stars. The light-ratio of the magnitude scale employed is 2·512.

Observations of U *Geminorum.*

Date.		Mag.	Remarks.
	h m		
Dec. 3 1867,	9 20 G.M.T.	under 13	Not seen.
7	10 25	9·4	U bluish white, disk ill-defined.
12	11 10	9·6	Moonlight, and clouds troublesome.
18	8 0	11·05	U rather large for its mag., shining with a dull bluish white light.
22	8 45	13·7	Rather brighter at intervals?
27	11 10	14·0	
31	10 55	14 ±	Feebly glimpsed. Sky rather hazy.

The observations are not sufficiently numerous to enable me to determine the date of maximum with great nicety, it would

appear, however, to have occurred on December 8th, about nine days later than the calculated date of maximum deduced from the elements given by Dr. Schönfeld in his "Catalogue of Variable Stars."

The rapidity with which this remarkable star goes through its changes, the irregularity of its period, its hazy appearance and peculiar hue, and the curious fluctuations of brightness in short intervals of time which have been sometimes observed, point it out as an object well worthy of careful attention on the part of astronomers.

It is much to be wished that observations of its spectrum could be obtained, as the peculiarity of its appearance suggests the probability that its spectrum would be found to be characterised by the presence of *bright lines.*

Woodcroft Observatory, Cuckfield,
January 9, 1868.

Companion to γ Equulei. By G. Knott, Esq.

On the 9th of July, 1867, I discovered a minute and pretty close companion to γ *Equulei*, which, so far as I am aware, had not been previously observed. Measures with a parallel wire micrometer on the same evening, and on that of July 27th, gave the following mean results:—

$$P = 276^{\circ}{\cdot}84, \text{ obs. } 11, \text{ w. } 53;\; D = 2''{\cdot}131, \text{ obs. } 8, \text{ w. } 24;\; \text{Epoch } 1867{\cdot}54.$$

The small star is about the 11th magnitude (corresponding with about the 10th mag. of Struve's Scale), and its colour, a fine clear blue, contrasts finely with the pale yellow of the primary.

Woodcroft Observatory, Cuckfield,
January 9, 1868.

Ephemeris for the Opposition of Iris, 1868, *computed from his Tables of Iris.* By F. Brunnow, Esq., Astronomer Royal for Ireland.

Berlin M.T.	App. R.A.	App. Decl.	Log. Dist. from Earth.
	h m s	° ′ ″	
1868, March 27·5	13 30 11·15	−17 2 22·7	0·28340
28·5	29 19·43	16 57 40·6	0·28252
29·5	28 27·03	16 52 49·6	0·28170
30·5	27 34·00	16 57 50·0	0·28094
31·5	26 40·39	−16 42 41·9	0·28025

Berlin M.T.	App. R.A. h m s	App. Decl. ° ′ ″	Log. Dist. from Earth.
April 1·5	13 25 46·27	−16 37 25·8	0·27962
2·5	24 51·69	16 32 1·9	0·27905
3·5	23 56·71	16 26 30·6	0·27855
4·5	23 1·39	16 20 52·2	0·27811
5·5	22 5·79	16 15 6·9	0·27773
6·5	21 9·97	16 9 15·0	0·27742
7·5	20 13·98	16 3 16·8	0·27718
8·5	19 17·87	15 57 12·7	0·27700
9·5	18 21·71	15 51 2·8	0·27689
10·5	17 25·55	15 44 47·7	0·27684
11·5	16 29·44	15 38 27·7	0·27686
12·5	15 33·46	15 32 3·1	0·27695
13·5	14 37·65	15 25 34·3	0·27711
14·5	13 42·09	15 19 1·8	0·27733
15·5	12 46·81	15 12 26·0	0·27762
16·5	11 51·89	15 5 47·4	0·27797
17·5	10 57·37	14 59 6·2	0·27839
18·5	10 3·31	14 52 22·9	0·27888
19·5	9 9·77	14 45 37·7	0·27943
20·5	8 16·81	14 38 51·2	0·28005
21·5	7 24·50	14 32 3·7	0·28073
22·5	6 32·87	14 25 15·8	0·28148
23·5	5 41·99	14 18 27·9	0·28228
24·5	4 51·89	14 11 40·5	0·28315
25·5	4 2·63	14 4 53·9	0·28408
26·5	3 14·26	13 58 8·6	0·28507
27·5	2 26·81	13 51 25·1	0·28612
28·5	13 1 40·33	−13 44 43·9	0·28723

Opposition, April 12, $12^h\ 3^m\ 34^s{\cdot}8$ Berlin M. Time.

The Lunar Crater Linné. By Capt. W. Noble.

Since the appearance of Mr. Birt's letter in the 27th volume of the *Monthly Notices*, p. 93, "On the Obscuration of the Crater *Linné*," I have (in common, I suppose, with every possessor of a telescope) from time to time examined *Linnæus*, with a view to detecting any change which might conceivably be in progress in it. Up to a very recent period, indeed, all such examinations have had an entirely negative result. In the place where Beer and Mädler depict an annular crater I have hitherto seen nothing but a small ill-defined white patch or spot, with soft edges; presenting,

even under the most favourable illumination, the aspect of any other small crater, near the centre of the lunar disk, at the time of full Moon, though without the sharpness of outline which would characterize it.

Subsequently to reading the paper by my friend Mr. Huggins, too, at p. 296 of the last volume of the *Notices*, I made an attempt to get a glimpse of the minute crater which he there depicts, but, as before, without effect. Ultimately I made up my mind that my optical means were insufficient for the scrutiny, and gave myself very little more trouble about it.

It was with no small surprise then, that, on looking at the *Mare Serenitatis*, at 5^h on the evening of Sunday, the 3rd November, I was struck by seeing *Linnæus* as an unmistakeable shallow crater, of somewhat elliptical form, and with the S.W. part of its surrounding wall rather thicker than the remaining portion. The floor of the crater was identical in tint with the surrounding *Mare*, and the effect presented at once suggested the aspect of the well-known nebula 57 *Messier*, between β and γ *Lyræ*. I was employing a power of 154 on my 4·2-inch achromatic of 61 inches focal length, when I first caught sight of *Linné*, but exchanged this for one of 255 for confirmation of detail. It is with the last-named power that the accompanying sketch* was made. I did not attempt any micrometrical measurements, but contented myself by drawing, with my eye at the telescope, what I saw at moments of the best vision. The extreme shallowness of *Linnæus* was curiously shown by the contrast presented by the remarkable blackness of the shadows of the minute craters to the north of it.

The Lunar Crater Linné. By J. Joynson, Esq.

On the 1st January, 1868, at 8^h P.M., it was not easy to make out where *Linné* exactly was in the field of the telescope, and when found it was far from being bright, and looked ill-defined and flattish. It appeared as though it was situated in a sort of trough formed by two "veins" or "ridges," that trended past it about due South, which "veins" were judged to be higher than *Linné* itself, particularly that on the western side.

On the 3d January the above-mentioned "veins" could not be found, but *Linné* itself was distinctly seen as a small black crater very well defined, surrounded by the usual hazy brightness. The following and south following part of the crest of the crater was the brightest, but the whole crest looked bright by contrast with the deep blackness of the centre. The crater lays rather south preceding the middle of the hazy brightness; but when it

* The sketch referred to closely resembles that given by Mr. Huggins, vol. xxvii. p. 296.—*Ed.*

was best seen, it looked as if the brightness was not so extensive as it usually appears, and the crater itself was very near the centre of it.

The crater was found with a positive eye-piece of a power of about 400; and though it was afterwards seen with the ordinary eye-pieces, both negative and positive, yet it was with considerable difficulty, and would certainly not have been made out with them. I think it was best seen when the rest of the Moon's surface was a very little out of focus.

As the Moon got up to and past the meridian, it became more difficult to make out the crater; and at $7^h 40^m$ P.M. it required considerable attention to make it out at all, even with the beforementioned eye-piece. At $7^h 15^m$ there appeared to be just above the crater a bright "spur" projecting out of the hazy brightness." The shallow crater could not be seen.

From what I have observed to-night, I am confirmed in the belief that there has been no change at all in *Linné* itself. The difference has been in observers, their instruments, and time of observation. I am convinced that I never should have seen the crater if I had not had this eye-piece, which, however, does not belong to the telescope. I use it with the microscope, and it was quite by chance that I have lately adapted it to and used it with the telescope. With the other eye-pieces *Linné* appears exactly as it did when I first observed it a year ago.

The measures of the whole brightness gave $4''{\cdot}42$, and those for the small black crater gave $1''{\cdot}223$; but I had to measure with the ordinary eye-pieces in the micrometer, which did not show it so well as might have been wished.

Waterloo, January 3, 1868.

On a Contrivance for reducing the angular Velocity of Meteors, so as to facilitate the observation of their Spectra. By John Browning, F.R.A.S.

When detailing to the Society some experiments I made, attempting to determine the characteristics of the spectra of the meteors of 1866, I stated that the great obstacle to any accurate observation arose from the enormous velocity with which the meteors travelled. This obstacle I have tried various means to overcome.

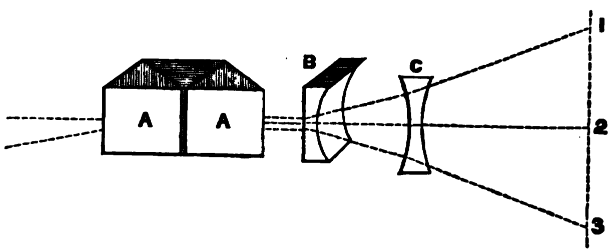
The contrivance I have found most promising consists of a direct-vision prism, having in front of it a deep concave cylindrical lens, and in front of that a double convex lens of the ordinary kind. Both these lenses should be either achromatic, or else made of optical crown glass of the lowest dispersive power.

The action of this piece of apparatus will become apparent upon referring to the accompanying diagram.

In this diagram A A represents a compound direct-vision prism; B, a plano-concave cylindrical lens; C, a double-concave lens with spherical curves of a much less curvature.

The dotted line represents the path of a meteor; the figures 1, 2, 3. three points in its path, and the lines proceeding from these three points, the manner in which the rays proceeding from the meteor are acted upon by the lenses and converged, so as to produce a comparatively stationary image in the prism.

The lens C, is useful in two ways. It assists in the converging action required, thus increasing the field, and it greatly improves the definition of lines in spectra, by bringing rays at right angles nearer to the same focus.



With the apparatus I have just described I have found it easy to obtain the spectra of balls shot from a Roman candle placed only a few yards off from the instrument. The angular velocity of the projected balls under these conditions is, of course, very great, yet the characteristic lines of baryta, strontia, &c., can be readily distinguished in their spectra.

I have the pleasure of exhibiting the apparatus adapted to a spectroscope similar to those I have made for the Royal Society under Mr. Huggins' instructions.

Our opportunities of observing meteors being very few, I have made this adaptation, so that the same apparatus may be used for various purposes.

The Meteor Epoch of November 13–14, 1867.
By V. Fasel, Esq.

The early part of the night of November 13–14 was not very favourable, the sky being rather overcast. Soon after 8^{h} P.M. it nevertheless cleared up so much as to induce me to make due preparations for keeping watch for the expected shower of meteors. After obtaining the true time from a transit of *Polaris* and other stars, I took my post outside the Observatory. What follows were the results of my watch:—

Nov. 13, at 11^{h} 40^{m} P.M. Wind E. b. N; high thin cirri in

W. S.W. current passed over the Moon, and when 10° East of it, they remained stationary for several minutes, and then gradually vanished.

$11^h\ 41^m$ P.M. (G.M.T.). A meteor of the second magnitude shot from above the Pointers in *Ursa Major*, and travelled about 12° due South, towards *Castor* and *Pollux*. Its colour was red: it left a train of red light.

Nov. 14, $0^h\ 11^m$ A.M. Some light whitish clouds appeared in S.E. They came *rapidly* towards the Moon in a N.W. direction.

$0^h\ 13^m$ A.M. A lunar corona, lightly coloured.

$0^h\ 15^m$ A.M. Sky partially overcast with rapid flying thin scud in S.S.E. current.

$0^h\ 30^m$ A.M. Sky overcast. At $0^h\ 40^m\ 28^s$ A.M., saw through the clouds a stationary meteor, which was visible between two or three seconds. Its position must have been in the constellation *Leo*. Its colour was red, and of the size of a tennis-ball.

From $0^h\ 40^m\ 28^s$ to 3^h A.M. the sky was quite overcast, but the Moon remained visible through the light clouds that continued to fly rapidly in S.E. current.

From 3^h A.M. to $4^h\ 30^m$ the Moon was invisible.

$4^h\ 45^m$ A.M. Sky clearing up; a few stars visible.

5^h A.M. Fog coming on.

6^h A.M. Dense fog. Observations discontinued.

Clapham Observatory, November 14, 1867.

Meteoric Shower, November 1867, *observed at the Cape of Good Hope.* By G. W. H. Maclear, Esq.

I forward the results of the watches for the November Meteoric Shower, kept up at this Observatory on the nights of the 12th, 13th, 14th, and 15th.

Nov. 12th. Commenced watch at 8^h P.M., Cape Mean Time, terminating at daylight; only three meteors were observed, viz.—

h m					
11 4	from	Taurus	to	Horizon	Large, blue and white.
11 45	,,	Procyon	,,	Northward	,, red.
11 55	,,	Zenith	,,	Westward	Very large.

Bright moonlight, and violent S.E. wind throughout.

Nov. 13th. Commenced watch $10^h\ 45^m$, terminating at daylight; nine meteors observed, viz.—

h m s					
11 49 5	from	α Ceti	to	α Andromedæ	Small.
‑1 50	,,	α Columbæ	,,	S. Pole	Larger, purple and white.
14 48	,,	Regulus	,,	S. Cross	Very fine, green train.

h m					
14 51	from	Procyon	to	Gemini	Small.
15 35	,,	betw. Regulus and α Hydræ to β Corvi			Small.
15 41	,,	Regulus	to	Arcturus	Small, curved.
15 46	,,	,,	,,	Spica	Small.
15 49	,,	,,	,,	Gemini	,,
15 49	,,	,,	,,	,,	,,

Bright moonlight; very hazy low E.; violent S.E. wind throughout.

Nov. 14th. Seventeen meteors observed, principally from *Leo*.

h m s					
13 52 0	from	η Leonis	to	Regulus	Orange and green; small.
14 3 0	,,	below Procyon to Spica			,, ,, ,, ,,
14 9 0	,,	Procyon	to	Southward	White; long train.
14 18 0	,,	γ Leonis	,,	Spica	Bright; short period.
14 18 22	,,	η Leonis	,,	Gemini	Faint.
14 37 17	,,	Leo	,,	β Corvi	Bright.
14 51 52	,,	γ Leonis	,,	Spica	Small.
14 58 52	,,	,,	,,	,,	,,
15 7	,,	Leo	,,	Procyon	Very small.
15 13	,,	ι Leonis	,,	N.E.	,,
15 14 22	,,	Leo	,,	β Corvi	Green; short period.
15 17 17	,,	about 8° below Regulus to Spica			Large.
15 19 57	,,	Leo, below β Corvi, to Southward			,,
15 27 37	,,	ζ Leonis	,,	N.E. horizon	,,
15 30 7	,,	Leo	,,	Spica	Small.
15 33 52	,,	below Gemini	,,	Capella	,,
15 34 32	,,	above Regulus to Procyon			,,

Fine moonlight night; wind abated; sky clear.

Nov. 15th. Five meteors observed, viz.—

h m s					
12 36 44	from	α Hydræ	towards	Spica	Small
12 39 49	,,	Procyon	,,	Leo	,,
13 27 39	,,	Gemini	,,	N. horizo	,,
13 45 44	,,	α Orionis	,,	,	,,
14 25 44	,,	Aldebaran	,,	,,	,,

Fine calm night; bright moonlight.

The station, as before, was on the roof of the Observatory, with an uninterrupted view of the horizon.

Royal Observatory, Cape of Good Hope,
November 19, 1867.

Meteoric Shower, November 1867, A.M., *off Martinique, West Indies.* Lat. 10° 44′, Long. 61° 11′ W.; Time $5^h\ 20^m$ to $6^h\ 15^m$ A.M. Local Time. Communicated by Commander W. Chimmo, commanding H.M.S. Gannet.

Rounding the north point of Martinique at 5 in the morning of the 14th November, while sitting on the bridge, I saw an immense number of bright sparks falling into the sea, at apparently a short distance from the ship, which I thought came from the ship's funnel, as they resembled those of sparks caused by the burning of wood.

I took no further notice until my attention was arrested by a brilliant meteor bursting in the East and emitting sparks like those of a rocket, shooting in a North direction at an altitude of about 37 degrees, and at an angle of 75 with the horizon.

I then called the attention of the First Lieutenant and Master, who were on the bridge at the time, to the meteoric shower then in view, falling rapidly and perpendicularly; every now and then a brilliant meteor bursting and lighting up the whole heavens. It was in reality a grand sight of fireworks.

The spot of blue sky from which they fell was about one-sixteenth of the whole heavens, and from the edge of a dark cloud of nimbus which was hanging over the island.

I merely send this as a simple notice for record, that the shower was seen at this place; but on board a ship, in the anxiety and excitement of going into a strange harbour, was not the time nor place to make any detailed observations.

This shower was much more distinctly seen at Trinidad on the same morning, from 2 A.M. to daylight, when 1600 were counted, and about eight per cent thought to have been missed. The meteors seen were numerous in the N.E., describing arcs of 60°. Some were of a reddish hue; others green, and one of a bright fiery purple, lasting many seconds. From midnight till $5^h\ 30^m$ A.M. 693 meteors were counted; 23 per cent were of the brightest description.

Trinidad, November 26, 1867.

Meteoric Shower, November 1867, *observed at Nassau, Bahamas.* By Captain Stuart.

(*Communicated by Samuel Lawson, Esq.*)

I forward for the information of the Society a table showing the character of the meteoric shower, as observed here on the morning of the 14th inst. The observer, an intelligent and experienced nautical man, was not advantageously placed for an extensive view of the heavens; and two other observers in a better position counted 1100 meteors between $2^h\ 30^m$ and $4^h\ 45^m$ A.M., up to which time Captain Stuart had counted only 800.

They observed them all round the heavens, from N.W. to S. and some overhead. From 4 A.M. the meteors appeared to radiate principally from a centre a little to the S.E. of the zenith, and shot in all directions. The position of Nassau is 25° 5′ N. lat. and 77° 22′ W. long. S. L.

Government House, Nassau,
22nd November, 1867.

Observations with regard to the Meteoric Shower taken at Nassau, N.P., Bahamas (Lat. 25° 5′ N., Long. 77° 22′ W.), on the morning of the 14th Nov. 1867, by Captain Stuart, Deputy Inspector of Lighthouses.

	Proportion of sky clear.	Length of each period.	Number of Meteors seen: In each period.	Number of Meteors seen: Total from Commencement
		h m		
13th Nov. 11 0 P.M.	·3	...	...	...
14th Nov. 1 0 A.M.	...	...	...	...
At 1 32	...	...	1 *a*	1
,, 1 45	...	13	1 *b*	2
,, 1 50	...	5	1 *c*	3
,, 1 57	...	5	1	4
,, 2 0	·5	7	1	5
Before 3 0	...	3	17	22
,, 3 15	...	1 0	23	45
,, 3 30	...	15	52	97
,, 3 40	...	15	32	129
,, 3 50	·6	10	34	163
,, 4 0	...	10	49	212
,, 4 10	...	10	118	330
,, 4 15	...	10	125	455
,, 4 20	...	5	102	557
,, 4 25	...	5	73	630
,, 4 30	...	5	69	699
,, 4 35	...	5	66	765
,, 4 40	...	5	21	786
,, 4 50	...	10	52	838
,, 5 0	·8	10	64	902
,, 5 10	...	10	65	967
,, 5 20	...	10	22	989
,, 5 30	...	10	46	1035
,, 5 34	...	4	5	1040

REMARKS.

a. About 20° E. by N. from *Sirius*, whose altitude was 43° E. of meridian. Direction from N. to S.

b. 10° E. by N. from Polar Star. Altitude 25°, N. to S.

c. In the Great Bear, E. to W.

The proportion of sky visible to the observer, who was only a few feet above the level of the sea, was about ·6.

The Moon shone very bright between $3^h 45^m$ A.M. to daylight. She was about 30° W. of that part of the heavens, where the meteors were chiefly seen.

The direction of the meteors was N. to S. and E. to W., chiefly in that part of the heavens where the Constellation of the *Polar Bear* was, at the altitude of 45°.

No atmospheric or magnetic disturbance was caused by the Meteors while falling.

ERRATUM.

The Erratum, p. 16, should be as follows :—

Memoirs, Vol. XXXV.

In p. 25, columns 5 and 6 of the Table, Comparison with Struve's Stars (Place by Chart for 1826), of Star Struve 409, W. H. IV. 44,

For $3^h 31^m{\cdot}3$ 70° 48′, *read* $3^h 21^m +$ 79° 15′ ±.

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Printed by STRANGEWAYS and WALDEN, Castle St. Leicester Sq. and Published at the Apartments of the Society, Feb. 4, 1868.

MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

Vol. XXVIII. *February* 14, 1868. No. 4.

Rev. Charles Pritchard, M.A. F.R.S., President, in the Chair.

Charles Henry Brooks, Esq., Merton, Surrey;
George Stickland Criswick, Esq., Royal Observatory, Greenwich;
Lieut. Seymour Morse Davies, R.A., Upton Park, Slough; and
John Parnell, Esq., Hadham House, Upper Clapton,

were balloted for and duly elected Fellows of the Society.

Report of the Council to the Forty-eighth General Meeting of the Society.

Progress and present state of the Society:—

	Compounders.	Annual Contributors.	Non-residents.	Patroness, and Honorary.	Total Fellows.	Associates.	Grand Total.
December 31, 1866	173	278	14	4	469	47	516
Since elected ...	8	21	...	...	...	...	...
Deceased	−3	−6	−1	...	...	−1	...
Expelled	...	−1	...	...	...	...	...
Resigned	...	−5	...	...	...	...	...
Removals	+1	−1	...	...	...	...	...
Dec. 31, 1867 ...	179	286	13	4	482	46	528

Mr. Whitbread's Account as Treasurer of the Royal Astronomical Society, from January 1 to December 31, 1867:—

RECEIPTS.

	£	s.	d.	£	s.	d.
Balance of last year's account	95	14	7			
Plus: Pearson's cheque lost and unpaid, for which a second cheque was given	2	10	0			
				98	4	7
By Dividend on £2800 Consols	41	6	0			
By ditto on £5000 New 3 per Cents ...	73	15	0			
By ditto on £2800 Consols	41	6	0			
By ditto on £5000 New 3 per Cents ...	73	15	0			
				230	2	0
On account of arrears of contributions ...	199	10	0			
176 annual contributions	368	11	0			
28 admission-fees	58	16	0			
19 first years' contributions	33	12	0			
	660	9	0			
10 compositions	207	18	0			
				868	7	0
Sale of publications				80	12	6
				£1277	6	1

EXPENDITURE.

	£	s.	d.	£	s.	d.
Salaries:—						
Editor of Publications	60	0	0			
Assistant Secretary	115	0	0			
Commission on Collecting	37	1	0			
				212	1	0
Taxes:—						
Land and Assessed	6	11	0			
Income	1	13	4			
Poor Rate	11	13	4			
Other Parish Rates	3	19	2			
				23	16	10
Repairs:—						
Boobbyer, ironmonger	3	2	0			
				3	2	0
Bills:—						
Strangeways and Walden, printers ...	601	17	8			
Rumfitt, bookbinder	12	5	1			
Basire, engraver	52	3	6			
Pearson, wood-engraver	8	2	0			
Joyce	1	5	0			
J. Beck	2	0	0			
Johnson and Co., engravers	13	13	0			
Wyon, medals	57	15	0			
Annual Dinner (deficiency)	18	12	0			
Insurance	10	0	6			
				777	13	9
Miscellaneous items:—						
House expenses	22	6	3			
Postages	42	12	6			
Books and parcels	3	14	5			
Expenses of evening meetings	13	13	0			
Waiters attending meetings	3	17	0			
Coals and wood	12	0	0			
Gas	5	4	10			
Repairs	5	8	0			
Sundries	16	7	2			
				125	3	2
Turnor Fund	3	12	3			
Mrs. Jackson's annuity, 1 year	8	13	4			
Mrs. Maynard. Gift	5	0	0			
				17	5	7
Cheque-book				0	5	0
				1159	7	4
Balance at Banker's				117	18	9
				£1277	6	1

Examined and found correct, 1868, February 3,
EDWIN DUNKIN, } *Auditors.*
Examined and found correct, Feb. 10th, 1868,
JOHN BROWNING, } *Auditors.*

Assets and Present Property of the Society, January 1, 1868:—

	£ s. d.	£ s. d.
Balance at Banker's		117 18 9
2 Contributions of 6 years' standing ...	25 4 0	
12 „ 4 „	100 16 0	
19 „ 3 „	119 14 0	
25 „ 2 „	105 0 0	
41 „ 1 „	86 2 0	
2 admission-fees, and first contributions ...	6 6 0	
		443 2 0
Due for Publications		2 14 6
£5000 New 3 Per Cents (including Mrs. Jackson's Gift, £300).		
£2800 Consols, including the Lee Fund (£100) and Turnor Fund (£500).		
Unsold Publications of the Society.		
Various astronomical instruments, books, prints, &c.		
Balance of Turnor Fund (included in Treasurer's Account)		112 11 6

Stock of volumes of the *Memoirs*:—

Vol.	Total.	Vol.	Total.	Vol.	Total.
I. Part 1	14	XI.	191	XXIV.	192
I. Part 2	54	XII.	198	XXV.	202
II. Part 1	72	XIII.	210	XXVI.	210
II. Part 2	36	XIV.	400	XXVII.	449
III. Part 1	89	XV.	179	XXVIII.	425
III. Part 2	108	XVI.	204	XXIX.	446
IV. Part 1	108	XVII.	201	XXX.	200
IV. Part 2	120	XVIII.	183	XXXI.	184
V.	134	XIX.	195	XXXII.	212
VI.	155	XX.	188	XXXIII.	224
VII.	179	XXI. Part 1	316	XXXIV.	230
VIII.	165	XXI. Part 2	100	XXXV.	415
IX.	168	XXI. (together).	97	XXXVI. (with M. N.)	483
X.	181	XXII.	187	XXXVI. (without)	120
		XXIII.	186		

The instruments belonging to the Society are as follows:—

The *Harrison* clock,
The *Owen* portable circle,
The *Beaufoy* circle,
The *Beaufoy* transit,
The *Herschelian* 7-foot telescope,
The *Greig* universal instrument,
The *Smeaton* equatorial,
The *Cavendish* apparatus,
The 7-foot Gregorian telescope (late Mr. Shearman's),
The Variation transit (late Mr. Shearman's),
The Universal quadrant by Abraham Sharp,
The *Fuller* theodolite,
The Standard scale,
The *Beaufoy* clock, No. 1,
The *Beaufoy* clock, No. 2,
The *Wollaston* telescope,
The *Lee* circle,
The *Sharpe* reflecting circle,
The *Brisbane* circle.

The *Sheepshanks'* collection of instruments, viz.,—

1. 30-inch transit, by Simms, with level and two iron stands.

2. 6-inch transit theodolite, with circles divided on silver; reading microscopes, both for altitude and azimuth; cross and siding levels; magnetic needle; plumbline; portable clamping foot and tripod stand.

3. $4\frac{6}{10}$ achromatic telescope, about 5 feet 6 inches focal length; finder, rack motion; double-image micrometer; object-glass micrometer; two other micrometers; one terrestrial and ten astronomical eyepieces, applied by means of two adapters, with equatorial stand and clock movement.

4. $3\frac{1}{4}$-inch achromatic telescope, with equatorial stand; double-image micrometer; one terrestrial and three astronomical eyepieces.

5. $2\frac{3}{4}$-inch achromatic telescope, with stand; one terrestrial and three astronomical eyepieces.

6. $2\frac{3}{4}$ achromatic telescope, about 30 inches focus; one terrestrial and four astronomical eyepieces.

7. 2-foot navy telescope.

8. 45-inch transit instrument, with iron stand, and also Y's for fixing to stone piers; two axis levels.

9. Repeating theodolite, by Ertel, with folding tripod stand.

10. 8-inch pillar-sextant, divided on platinum, with counterpoise stand and horizon roof.

11. Portable zenith instrument, with detached micrometer and eyepiece.

12. 18-inch Borda's repeating circle, by Troughton.

13. 8-inch vertical repeating circle, with diagonal telescope, by Troughton and Simms.

14. A set of surveying instruments, consisting of a 12-inch theodolite for horizontal angles only, with extra pair of parallel plates; tripod staff; in which the telescope tube is packed; repeating table; level collimator, with micrometer eyepiece; and Troughton's levelling staff.

15. Level collimator, plain diaphragm.

16. 10-inch reflecting circle, by Troughton, with counterpoise stand; artificial horizon, with metallic roof; two tripod stands, one with table for artificial horizon.

17. Hassler's reflecting circle, by Troughton, with counterpoise stand.

18. 6-inch reflecting circle, by Troughton, with two counterpoise stands, one with artificial horizon.

19. 5-inch reflecting circle, by Lenoir.

20. Reflecting circle, by Jecker, of Paris.

21. Box sextant and 3-inch plane artificial horizon.

22. Prismatic compass.

23. Mountain barometer.

24. Prismatic compass.

25. 5-inch compass.

26. Dipping needle.

27. Intensity needle.

28. Ditto ditto.

29. Box of magnetic apparatus.

30. Hassler's reflecting circle, with artificial horizon roof.

31. Box sextant and $2\frac{1}{4}$-inch glass plane artificial horizon.

32. Plane speculum artificial horizon and stand.

33. $2\frac{1}{2}$-inch circular level horizon, by Dollond.

34. Artificial horizon roof and trough.

35. Set of drawing instruments, consisting of 6-inch circular protractor; common ditto; 2-foot plotting scale; two beam compasses and small T square.

36. A pentagraph.

37. A noddy.

38. A small Galilean telescope, with the object lens of rock-crystal.

39. Six levels, various.

40. 18-inch celestial globe.

41. Varley stand for telescope.

42. Thermometer.

43. Telescope, with the object-glass of rock crystal.

These are now in the apartments of the Society, with the exception of the following, which are lent, during the pleasure of he Council, to the several parties under mentioned, viz.:—

The *Fuller* theodolite, to the Director of the Sydney Observatory.

The *Beaufoy* transit, to the Observatory, Kingston, Canada.

The *Sheepshanks* instrument,		No. 1, to Mr. Lassell.
Ditto	ditto	No. 2, to Mr. De La Rue.
Ditto	ditto	No. 3, to Major Tennant.
Ditto	ditto	No. 4, to Rev. C. Lowndes.
Ditto	ditto	No. 5, to Mr. Birt.
Ditto	ditto	No. 6, to Rev. J. Cape.
Ditto	ditto	No. 8, to Rev. C. Pritchard.
Ditto	ditto	No. 9, to the Director of the Sydney Observatory.
Ditto	ditto	No. 41, to Rev. C. Pritchard.
Ditto	ditto	No. 43, to Mr. Huggins.

The 6-inch circular protractor, to Mr. Birt.

The Gold Medal.

The Council have awarded the Gold Medal to M. Leverrier for his Solar and Planetary Tables. The President will, in the usual way, explain the grounds of this award.

Printed Transactions of the Society.

Two volumes of *Memoirs* have been published since the last Report. Volume XXXV. contains four papers. Two of them are by Sir Thomas Maclear of observations made at the Cape of Good Hope. The former of these consists of the "Mean North Polar Distances of *Rigel*, *α Orionis*, *Sirius*, and *α Hydræ*, for January 1 of each Year, derived from Observations with the Transit Circle, in the Years 1856–63." The second paper contains "Geocentric Right Ascensions and North Polar Distances of Encke's Comet." The third paper is a valuable "Synopsis of all Sir William Herschel's Micrometrical Measurements and Estimated Positions and Distances of the Double Stars described by him, together with a Catalogue of those Stars, in order of Right Ascension, for the Epoch 1880·0," by Sir John F. W. Herschel.

This volume also contains, from the pen of the Rev. W. R. Dawes, a very important and extensive "Catalogue of Micrometrical Measurements of Double Stars, comprising all the measures obtained by him between the close of his Second Series (published in the *R. A. S. Memoirs*, vol. xix.) and the present time."

Volume XXXVI. consists of the observations made by Mr. Lassell during his last sojourn at Malta. These observations are arranged in three papers: I. Observations of Planets and Nebulæ; II. Miscellaneous Observations; III. A Catalogue of New Nebulæ discovered at Malta. Mr. Lassell's observations are illustrated by eleven plates.

Obituary.

The Society has to regret the loss by death of the following Fellows and Associate:—

Fellows.—The Earl of Rosse.
Lord Wrottesley.
Sir James South.
Rev. W. R. Almond.
Rev. Dr. Nicholson.
Mr. William Brooke.
Mr. J. J. Downes.
Mr. Charles Howell.
Rev. Miles Bland.
Mr. Thomas Heelis.

Associate.—Dr. Bache.

A notice of the life and labours of Lord Rosse will appear, it is expected, in the *Monthly Notices* for April.

John, second Baron Wrottesley, was the eldest son of Sir John Wrottesley, Bart., of Wrottesley, near Wolverhampton, in Staffordshire, who was raised to the Peerage as Baron Wrottesley. He was born on the 5th of August, 1798, and graduated first class in Mathematics at Oxford in 1817, being a Member of Corpus Christi College. He succeeded his father in the Barony on the 16th of March, 1841.

Taking much interest in Practical Astronomy, he became, as Mr. John Wrottesley, an original Member of this Society, and contributed various observations, chiefly of the stars, to its *Monthly Notices* and *Memoirs*. In the year 1829 he commenced the erection of an Observatory at Blackheath, where he began to observe, assisted by Mr. John Hartnup (afterwards Assistant-Secretary to the Royal Astronomical Society and now Astronomer of the Observatory at Liverpool), in the spring of 1831; having a transit-instrument by Thomas Jones, of 62 inches focal length, and clear aperture $3\frac{1}{4}$ inches, and a clock by Hardy. Being provided with such means of making astronomical observations, he determined to fix upon some definite object, and steadily pursue that alone. He, accordingly, selected 1318 stars from the Astronomical Society's Catalogue of 2881, being the stars of the sixth, and from that to the seventh magnitude inclusive, resolving to determine their right ascensions, observing, if possible, each star at least ten times. Having ascertained everything necessary to be known respecting the qualities of the instruments about to be employed, Mr. Wrottesley began the observation of his Catalogue on the 9th of May, 1831, and on the 1st of July, 1835, the task was brought to a conclusion. The Catalogue so produced embodies the results of 12,007 observations, exclusive of those of the stars required for comparison. It was read before this So-

ciety on the 11th November, 1836, and published in the Society's *Memoirs*, vol. x.

The Council awarded the Gold Medal to the author, to whom it was presented by the President, the late Mr. F. Baily, at the Annual General Meeting of February 8, 1839, after he had delivered an appropriate address, in which he informed the Society that when the requisite comparisons had been made with the positions of the same stars obtained at the public observatories, —and every star in Mr. Wrottesley's Catalogue, he also stated, had undergone that investigation,—the result had shown that his Catalogue was of first-rate importance, and entitled to implicit confidence. A Supplemental Catalogue of the right ascensions of fifty-five Stars, also observed at Blackheath, appears in the 12th volume of the *Memoirs*. At the Annual Meeting of 1841, Mr. Wrottesley was elected President, in which capacity, after his accession to the title of Lord Wrottesley, he delivered two addresses, on the presentation of the Gold Medal to Professor Hansen, of Gotha, in 1842, for his researches in physical astronomy, and to Mr. F. Baily, in the following year, for the experiments in which he virtually repeated the Cavendish experiments to determine the mean density of the Earth. On April 29th, 1841, he had been elected a Fellow of the Royal Society.

In the beginning of the year 1842, Lord Wrottesley resolved on erecting an observatory near his residence, Wrottesley Hall; and on the 29th of March in that year, the first stone was laid by his youngest son, the late Cameron Wrottesley, Lieut. R.A., who had distinguished himself by his mathematical attainments, and had begun his career as an astronomical observer, which was unhappily terminated by his being killed at the siege of Bomarsund in 1854. The observatory was designed to contain the transit-instrument, with which the stars of the Blackheath Catalogue had been observed, and an equatorial telescope, with rooms for the observer. The observatory is described, and a plan of it given, in the introduction to the Catalogue of Stars in that of the British Association, of which an account is subjoined. The telescope is an achromatic, of 10 feet 9 inches focal length, with an object-glass of 7¼ inches clear aperture, of which the flint-glass is by Guinand and the crown by the elder George Dollond, who gave the curves to the glasses and completed the instrument. The years which immediately succeeded the foundation of the Wrottesley Observatory were employed in obtaining its position (N. Lat. 52° 37′ 23″, Longitude West of Greenwich in time $8^m\ 53^s{\cdot}57$), and in observations with the equatorial, which Lord Wrottesley communicated to the Royal Society, and which have been published in the *Philosophical Transactions* for 1851. This communication is entitled, "On the Results of Periodical Observations of the Positions and Distances of Nineteen of the Stars in Sir John Herschel's Lists of the Stars favourably situated for the Investigation of Parallax, contained in Part iii. of the *Phil. Trans.* for 1826, and in Part i. of 1827." The inquiry to

which it relates constitutes another example of the mode of doing good service to Astronomy which Lord Wrottesley early prescribed to himself, and which he has steadily pursued.

Sir J. F. W. Herschel had shown in the papers referred to, and again in his Treatise on Astronomy, that if a star which is optically, though not physically, double (that is, one the component single stars of which appear in close proximity merely on account of their being nearly in the same line of sight, though at different distances from the eye, and not because, revolving about each other in orbits, they constitute a binary system), occupy a certain position with respect to the ecliptic, and one of the components be very much nearer the earth than the other, a considerable periodical and parallactic change will take place in their angle of position, or the angle made with the meridian, by a line drawn through both of them, and that the maximum variation from the mean position will occur at two opposite seasons of the year. Lord Wrottesley determined to devote his equatorial to a good trial of this method of discovering parallax, and six years' uninterrupted observing, from February 1843 to October 1849, by his assistant and himself, was given to the work. But the observations were attended with great difficulties, and of sixty-nine double stars selected, only forty-eight were observed, and only nineteen at both periods of the year. Of these again, the observations of five only deserved much attention, as exhibiting indications of parallax measurable by this method; but two of them, 32 *Eridani* and 95 *Herschel*, Lord Wrottesley finally recommended to the notice of astronomers provided with adequate instruments for observing them. Thus the principal result of the labour and assiduity bestowed on this object was the illustration of the practical difficulty of the method, and it demonstrated the impolicy of further perseverance, with the instrumental means of the Wrottesley Observatory, especially as instruments had been erected, both at Liverpool and Oxford, pre-eminently suited to this class of observations. But the zeal which prompted the employment of so much time and force by one astronomer, in the pursuit of a mode of research, proposed to observers by another, deserves the commendation of every lover of science. The paper is worthy of attention in another point of view. The importance to the correction and advancement of knowledge of recording failures, and imperfect success in research, has been insisted upon by the highest authorities; modern astronomers have been conspicuous in acting on this principle, and have thus encouraged labourers in other departments to submit to the task so unpleasing to themselves, though so beneficial to their successors; and the candour with which Lord Wrottesley has estimated the amount of success obtained in this arduous inquiry, is equalled only by the devotion and skill displayed in making and discussing the observations.

When the Star-Catalogue of the British Association appeared, he was anxious to perform the same office in respect to that most

valuable publication which he had already undertaken and performed in reference to the prior Catalogue of the Astronomical Society. For this purpose he selected 1009 stars, with the intention of obtaining, at least, five observations of each, being those stars which had already been observed at Blackheath, and had been discovered to possess proper motion, with others selected on various accounts.

The observations were begun on the 1st January, 1850, and concluded on the 24th December, 1853. They were all made and computed by Lord Wrottesley's assistant, Mr. Richard Philpott, an excellent transit observer, aided in the computations by his second assistant, Mr. Frederic Morton, who had charge of the equatorial. The results were communicated to the Royal Astronomical Society, read on the 13th of January, 1854, and published in vol. xxiii. of the *Memoirs*, being alluded to with great approbation by the Council in the Report for February 9th, 1855.

On the resignation of the late Earl of Rosse, Lord Wrottesley was proposed and chosen President of the Royal Society, at the Anniversary Meeting of 1854, and was re-elected to that office in the three following years. Having thus been placed at the head of the most ancient and venerable of British scientific institutions, he availed himself of the first opportunity afforded him, according to established usage, of addressing the Royal Society, at the Anniversary of 1855, of taking a review of some of the desiderata of science in this country, with respect both to the wants of the public, and to the interest and encouragement of the nation and the government. In his address of 1856, he resumed the consideration of the requirements and actual condition of scientific knowledge, in connexion with the occupation of Burlington House by the Royal Society, in conjunction with the Linnean and Chemical Societies of London, to which an improved appreciation of science on the part of the existing administration had conduced.

In 1859, Lord Wrottesley communicated to the Proceedings of the Royal Society a paper, "On the Application of the Calculus of Probabilities to the result of measures of the Position and Distance of Double Stars." He remarked in this paper that the differences between mean results obtained on different evenings were greater in proportion than those of the separate or partial measures obtained on the same evening, which arose from chance errors of observation; and that this circumstance rendered the application of the formulæ of the calculus of probabilities to the reduction of the observations, embarrassing and difficult. The observations made after 1851 fully confirmed this anomaly. As the observations of his Catalogue of Double Stars were drawing to a close, and it became extremely desirable that if there were any fault in the reductions or method of computing hitherto employed, it should be speedily remedied and the necessary corrections made, he requested and obtained the opinion as to the best

mode of proceeding, of the Astronomer Royal, who proposed a formula adequate to the difficulties of the case, which is given in the paper, but which, though the correct one, he thought was too elaborate to use in dealing with observations in which the errors of observation were large in amount, and in which such extreme accuracy in the results is not attainable, as in some other cases to which the principles of the Calculus of Probabilities are applicable. Mr. Airy suggested, therefore, that all the observations of the several nights should be combined together for the purpose of obtaining the probable error and weight of the final result, which might be done in two ways. Lord Wrottesley accordingly proceeded to ascertain the result of employing each of these three methods, by directing his assistant, Mr. Morton, to observe three stars a very great number of times. The results are subjoined to the paper, together with the whole computation and a summary of them. "It is hoped," the author remarks, "that this may not only prove interesting to observers of double stars, but may throw some light on the curious mathematical question involved in the inquiry which is the subject of the above remarks." It appears from the entire investigation that little effect is produced on the mean result for each star by using these different methods of reduction.

The "Catalogue of the Positions and Distances of 398 Double Stars," for the sake of which the preceding discussions here recited were instituted, appeared in our *Memoirs*, vol. xxix., having been read May 11, 1860. In the introduction the author states that from the beginning of the year 1857, the final means were obtained, and the probable errors and weights computed, by considering all the observations of the star, on the different nights, to have been made on the same night.

The observations for the Catalogue were made by means of the equatorial telescope already noticed. As a general rule, ten measures, both in position and distance, were made on the same night of each object, whenever they could be obtained, but from March 1856 to October 1858 the practice was to take six measures only of each element. The ten or six observations, as the case may be, are called a set. There are, in fact, two Catalogues, the first containing the results of the observations of each star, made on separate nights; the second, the general mean of all the sets obtained in the same year.*

The production of this Catalogue appears to have been the last considerable work in Astronomy of Lord Wrottesley.

Lord Wrottesley married on the 28th of July, 1821, Sophia Elizabeth, third daughter of the late Thomas Gifford, Esq., of Chillington, Staffordshire, and had a numerous family; of whom two sons lost their lives in their country's military service.

Lord Wrottesley died at his ancestral residence on the 27th of October last, aged sixty-nine. E. W. B.

* This Catalogue is noticed in the Report of the Council for February 8, 1861.

Sir James South was the son of a pharmaceutical chemist who carried on business in Southwark in the latter half of the last century. He was born in October 1785. After an ordinary course of education he entered upon the study of surgery, became a member of the College of Surgeons, and acquired an extensive practice and a reputation that promised eminence had he followed the profession. It is probable that his tastes were turned towards astronomy through an acquaintance which he early formed with Captain Huddart, a famous engineer, who, among other achievements, had constructed an equatorial mounting for a telescope with an object-glass of 3¾ aperture, made by Dollond, which instrument subsequently came into Mr. South's possession. Before obtaining this he had procured a 6-inch Gregorian reflector, with which he observed eclipses, occultations, and other phenomena. In 1816 he married the niece and sole heiress of Joseph Ellis, Esq., of South Lambeth, and, no longer dependent upon his profession, resolved to devote himself entirely to astronomical pursuits. He at once set about the formation of an observatory at his house in Blackman Street, Borough, and furnished it with the Huddart instrument above alluded to, a second telescope of 5 inches aperture, and a transit made for him by Troughton, upon the model of that which this eminent maker had recently constructed for the Royal Observatory, Greenwich; it was of 4 inches aperture and 7 feet focus, and, in regard to the just proportion of its parts, Troughton considered it as his happiest production.

Intent upon the useful employment of his time and resources, Mr. South resolved upon re-observing the double stars discovered and measured by Sir William Herschel. This appeared desirable, not only for the purpose of detecting changes of position, but on account of the improvement that had been wrought in the construction of measuring instruments since the epoch of the elder Herschel's observations. Sir John Herschel had projected a similar repetition of measures. A concerted plan of work was therefore agreed upon, and the observers began their labours in 1821, and continued them during the two following years. The result was the well-known Catalogue of 380 Stars, which was presented to the Royal Society in 1824, and printed at the expense of the Board of Longitude, and which was the standard work of its class till it was rivalled by that of Struve. Our Society rewarded Messrs. Herschel and South, jointly, with the Gold Medal for their labours in producing this Catalogue, which was honoured in like manner by the French Institute. Mr. South now entered upon a second series of similar observations; but finding the situation of his observatory not so good as he could wish for delicate work, he, in the autumn of 1824, transferred his larger instrument to Passy, near Paris, and worked there till towards the close of the following year, accumulating measures of 458 additional double stars. Upon his return to England, he observed for a time in Sloane Street, and made a

re-examination of some of his French measures; this second Catalogue was printed in the *Philosophical Transactions* for 1826.

While working in concert with Sir John Herschel upon the first Catalogue he was using his transit instrument for an investigation bearing upon the errors of the Solar Tables then in use. The discordances between observed and calculated right ascensions of the Sun were generally attributed to instrumental inaccuracies caused by the heating of the instrument during the observations. Crucial tests were, therefore, instituted by Mr. South to verify or refute this supposition. For a time transits were taken with every possible precaution to shield the telescope from unnecessary exposure to sunshine. Then the sun was purposely allowed to shine upon one-half of the instrument for intervals varying from a few minutes to an hour before the time of transit, and series of observations were taken under these conditions. The observed places were compared with tabular places, and it was found from a mean of two years' observations that the difference between the errors derived from observations with the instrument defended and exposed amounted only to 0·045 of a second of time: it was, therefore, concluded that the discordances in question were not due to instrumental derangement, but belonged entirely to the tables. His paper on this subject and his labours upon double stars formed the grounds for the award of the Copley Medal to him in 1826.

The existence of an atmosphere of very great extent surrounding the planet *Mars* had been inferred from some observations by Cassini and Roemer, both of whom noted a considerable diminution in the brightness of a fifth-magnitude star occulted by the planet in 1672. This record prompted Mr. South to watch for appulses of *Mars* and stars, and he was fortunate in observing two near approaches and one actual occultation. In no case was any diminution of lustre or alteration of colour of the star detected beyond what was fairly attributable to the brightness and colour of the planet. Mr. South considered that his observations sufficiently negatived the conclusion derived from that of Cassini, but he commended the subject to further investigation, which, however, it has not received. In February 1821 he observed a remarkable occultation of δ *Piscium* by the Moon, when the star was projected to a considerable extent upon the unilluminated disk. This induced him to collect all available observations bearing upon the vexed question of projection. He analysed the recorded cases with reference to several explanatory hypotheses, viz. existence of a spurious disk in the Moon's image; existence of a lunar atmosphere; irradiation; imagination on the part of the observer; and differences of refrangibility of the light of Moon and star, arising from differences of colour. His examination led him to conclude that each and all of these were untenable, and he left the question where he found it, excepting that he had brought together a mass of materials to help any future investigator. The

Astronomer Royal, Mr. Airy, turned these to account, and increased the store: he took up the subject with a predilection for Mr. South's last-mentioned hypothesis, but finding it unsatisfactory, gave his adhesion to that attributing the apparent projection to irradiation in conjunction with some unexplained condition of the observer's mind or eye. This contribution of Mr. South's to astronomical literature appears in the *Memoirs* of our own Society, to which he had previously communicated several papers, relating to observations of comets and phenomena, adjustment of instruments, and methods of observation. Apart from his contributions to our *Memoirs*, the name of South will for ever be inseparable from the history of our Society; he was one of its founders, and, in the position of President, petitioner for the Charter by which, in 1831, it was incorporated. Immediately after procuring the charter, however, he ceased to take part in the Society's proceedings; the cause of his secession being a difference, into which it is needless to enter, concerning the tenure of the Presidency.

About the year 1826 Mr. South sought a better location for his instruments, and purchased a site at Campden Hill, Kensington, upon which he erected a magnificent Observatory, one of the most complete that private taste has yet called for. Besides the instruments removed from Blackman Street, it was furnished with the Transit Circle used by Groombridge in the formation of his Catalogue, and a clock presented by the King of Denmark. Mr. South intended to have a first-class equatorial, and procured from France a 12-inch object-glass by Cauchoix. A dome was prepared to receive the instrument, the manufacture of which was intrusted to Troughton, in whom South had unqualified confidence. The transaction was a very unfortunate one; the equatorial turned out, in South's opinion, a failure; bitter enmities were aroused, and the payment of the manufacturer became the subject of a lawsuit: the verdict was unfavourable to South, who forthwith demolished the instrument: every part of the mounting was broken up or mutilated beyond renovation, and the *débris* was sold as old metal by public auction. The object-glass was presented to the Dublin Observatory in 1862.

It was in 1831, while this instrument was in course of construction, that the honour of knighthood was conferred upon South, on the recommendation of the Duke of Wellington, then Prime Minister; subsequently a pension of 300*l.* a-year was granted for his contributions to Astronomical Science.

The unhappy affair of the equatorial in a great measure alienated Sir James South from astronomical pursuits. He published no more observations, but he did some work with his meridian instruments; he also devoted much time to experiments upon clocks and pendulums, the results of which may yet be rendered serviceable by publication. In 1846, when a line of railway was projected to pass near the Greenwich Observatory, of which establishment Sir James was a Visitor, he made a series of obser-

vations at Watford upon disturbances produced by passing trains upon the images of stars reflected from mercury; these were reported to the Government at the time, and were presented to the Royal Society in 1863.

Sir James South was the author of several papers and pamphlets of critical nature and severe tone. One of these, published in 1822, was an exposition of the then defective state of the *Nautical Almanac* as compared with the Continental Ephemerides: this subject received considerable discussion, and ultimately a committee was formed, with Sir James as its chairman, to report to the Admiralty upon it. To the recommendations of that committee the present excellence of the *Nautical Almanac* is due. The "Thirty-six Charges" preferred by South, in 1830, against the President and Council of the Royal Society were less satisfactory; although they were strongly pressed and freely circulated, they were never supported, and no notice was taken of them. He printed some minor papers in the *Quarterly Journal of Science* and *Phillips' Annals of Philosophy.*

During the last years of his life he was afflicted with nearly total deafness and partial blindness; bodily sufferings still further weighed him down till he sank beneath them on the 19th of October, 1867. J.C.

ALEXANDER DALLAS BACHE was a great-grandson of the famous philosopher, Benjamin Franklin, and the son of Richard Bache, an able journalist. He was born at Philadelphia on the 19th of July, 1806. He graduated at the Military Academy at West Point, and at the end of the four years that determine the course of study at that institution, stood at the head of his class. The appointment of Assistant-Professor of Engineering in the Academy was immediately conferred upon him, but he held the chair for one year only. The education at West Point is gratuitous, but each cadet is expected to give eight years' service to the Government, unless he be sooner released: Bache served as a Lieutenant in the Corps of Topographical Engineers till 1827, when he was nominated to the Professorship of Natural Philosophy and Chemistry in the University of Pennsylvania. This post he occupied with distinguished success till the year 1836. The College and Asylum for Orphans, founded in Philadelphia by the princely bounty of Stephen Girard, was then springing into activity, and Professor Bache was made its President. Upon taking office he was at once deputed by the Trustees of the College to visit Europe, and inquire into the existing state of education in the schools of Great Britain and the Continent, especially those that bore similarity in objects and character to that under his control. Pursuing this mission, he made a tour through the important scholastic institutions of England and Scotland, France, Switzerland, Holland, Belgium, and the chief States of Germany; making also a rapid visit to Italy. Every detail of instruction and government was examined in the nume-

rous establishments of various classes that came under his inspection, and a large collection was made of text-books, instruments, models, drawings, and all other appliances for teaching that were likely to lend useful aid in fulfilling the wide intentions of the founder of the Girard Orphan School. The results of this inspection were embodied in a full and comprehensive report given to the world in the year 1839, and forming one of the most exhaustive summaries of orphan and general education ever produced, although it embraces but a portion of the materials that were collected for it.

During the Presidency of Professor Bache a Magnetic Observatory was established in connexion with this College, and, in 1840, a system of observations was commenced, in pursuance of the plan recommended by the British Association. Bache gratuitously directed these till his removal from Philadelphia in 1843, and after this he retained general superintendence of them till the series terminated in 1845. During the years 1840–41, he also made a detailed magnetic survey of Pennsylvania and the adjacent parts of New York, Ohio, and Maryland; determining the magnetic declination, dip, and intensity, at a number of stations suitably selected with regard to the course of isomagnetic lines. The discussion of these observations and of those made at Girard College were interrupted by the pressure of subsequent official duties, and were only completed after the lapse of many years.

In 1843 Dr. Bache entered upon that portion of his life's labours which has made his name famous throughout the scientific world. It was in 1807 that Congress passed an act authorising the Survey of the Coasts and Harbours of the United States. Plans of operation were invited from scientific men, and, of thirteen that were offered, one proposed by Mr. F. R. Hassler was accepted, its author being subsequently appointed to superintend the Survey. This he did with great zeal and ability, and the work might have been completed under his direction, but for its interruption for a period of nearly fifteen years, when he was in the prime of manhood and strength. Hassler died in 1843; Bache was at once appointed to succeed him. In entering upon his new duties, he expressed diffidence in his powers to do full justice to a work that his predecessor had created and made so peculiarly his own; but he resolved to apply himself to it with "entire devotion and unwearied energy," to quote his own words. The primary aim of the Coast Survey was to furnish, with the fullest possible accuracy, all the geographical, topographical, and hydrographical data that may in any way be needed for the navigation and defence of the coast. For the first of these are necessary the fixation of geographical positions by accurate astronomical determinations, the measurement of bases, and primary and secondary triangulations; for the second, minute plane table surveys and contourings; for the third, soundings off the coasts and in the bays, harbours, and other navigable waters

connected with the ocean, the charting of shoals, rocks, &c., and the determinations of the direction and velocity of currents. These field operations involve heavy office work, reduction of observations, map-drawing, engraving, and printing. The scientific preparation, the practical knowledge, and the administrative talent, necessary for the successful conduct of operations of such magnitude and complexity could have been found in few men: it is not too much to say that Bache possessed all these requirements. The national work, great and important as it was when he took charge of it, grew in importance under his command. Old instruments and methods were replaced by others embodying modern principles and refinements: foremost among these may be mentioned the electrical determination of longitudes, which was employed between the principal stations of the Survey in 1845, and in many subsequent cases in which the existence of telegraphic communication rendered it possible. As the work progressed additional duties were undertaken; some, as the supervision of lighthouses, buoys, and beacons, imposed by the Government; others, self-imposed. By husbanding the strength at his disposal, Bache, who was a hard worker and genially encouraged hard work in others, widely extended the range of subjects originally embraced by the Survey: he organised magnetic observations, and recorded meteorological data, earthquake phenomena, and, for a time, the appearance of Sun-spots. Although the principal share of his work will go to the furtherance of geographical knowledge, yet astronomy will indirectly benefit by it. Geodesy, too, will be advanced, for the Survey of the Atlantic Coast involves the measurement of an arc of latitude extending over twenty degrees. Terrestrial magnetism will profit by his extensive and systematic observations, and climatology by his comprehensive researches upon the movements of the Gulf Stream. His annual reports to Congress, increasing in extent and fulness as his labours neared completion, embrace an invaluable repertory of physical investigations, while they form a step-by-step history of the progress of a survey as certainly the most accurate as it is obviously the most extensive that has yet been produced or called for by any nation in the world.

Professor Bache contributed many memoirs, embodying the results of original researches in various branches of physical inquiry, to the American scientific journals, chiefly to *Silliman's Journal*, and the *Proceedings of the American Association for the Advancement of Science*. Of this Association he was twice President, and always a leading Member. He was an Associate of the principal learned Societies of Europe. In 1858 the Royal Geographical Society awarded him the Victoria or "Patron's" Medal for his labours in connexion with the Great Survey. When, in 1863, the National Academy of Sciences was established by Act of Congress to represent and direct the highest science of the country, the members of that body unanimously

elected him the first President for a period of six years. This period was unhappily cut short. His brain softened, it has been suggested from over-exertion, and, after a long and painful illness, he died at Newport, Rhode Island, on the 17th of February, 1867.

Wherever his name is mentioned it is coupled with expressions of admiration and respect. A high official of his Government said of him that "his genial disposition attracted the love of associates and subordinates: his wisdom commanded their respect. He leaves us a name of unsullied purity, and a memory that adds lustre to the many public records upon which it is borne." J. C.

The REV. HENRY JOSEPH BOONE NICHOLSON, D.D., an honorary Canon of Rochester Cathedral, was the son of the Rev. J. Payer Nicholson, formerly Rector of St. Alban's, to which Incumbency Dr. Nicholson was himself instituted in the year 1835. He was elected a Fellow of this Society in 1825, and was also a Fellow of the Society of Antiquaries and of the Numismatic Society. His attention was chiefly directed to antiquarian pursuits, and his *Handbook to the Abbey of St. Alban's* is a very able work, showing not only his thorough acquaintance with the various styles of architecture exhibited in the building, but a large amount of varied historical research. He died July 27, 1866, at the age of 71, universally regretted.

The REV. MILES BLAND, D.D., F.R.S., was one of the first Fellows of the Astronomical Society. He was born on Oct. 11, 1786, at Sedbergh, in Yorkshire, where his family had resided for many generations. The Blands of Sedbergh appear, from Carlisle's *Collections for a History of the Ancient family of Bland*, to have been the original stock of the family. Carlisle writes (p. 2): "The family of Bland is purely English, and of very high antiquity. . . . Their surname is derived from Bland, or Bland's-Gill, a hamlet in the chapelry of Howgill, and Parish of Sedbergh." And he mentions William de Bland as doing good service to King Edward III. in his wars in France; Thomas de Blande and Robert de Blande as specially included in a proclamation of Sept. 25, 1386, and charged to take care that no arms or horses were sold to the king's enemies from the North Riding of Yorkshire; Patricius de Bland, of Sedbergh (p. 5), as one of some gentlemen appointed in 1333 to raise and command troops for an expedition against the Scots. Of the Sedbergh Blands was (p. 5) John Bland, Rector of Adisham in Kent, who had for a pupil at Adisham Edwin Sandys, afterwards Archbishop of York, and was one of the sufferers in Queen Mary's reign, having been burnt at Canterbury on July 12, 1555.

Miles Bland was educated at Sedbergh School, from which he went to St. John's College, Cambridge, in October 1804. Private tuition at Cambridge was then little known. The great

mathematical tutor of the day was Mr. John Dawson, a retired surgeon of Sedbergh, and a self-taught mathematician. Cambridge students went to read with him at Sedbergh in the summer vacations, and sent problems and questions to him from Cambridge for his solutions. Dr. Bland was wont to say that Mr. Dawson had had eleven Senior Wranglers for his pupils, and intended him to be the twelfth; but he was second, in 1808, to Bickersteth, afterwards Lord Langdale. Blomfield, afterwards Bishop of London, was third; and Sedgwick, the present Professor of Geology at Cambridge, and Bland's schoolfellow at Sedbergh, was fifth. Bland was elected Fellow of his College in 1808, and in 1809 was appointed Assistant Tutor, and continued in the tuition, first as Assistant Tutor, and afterwards as joint tutor with Mr. Hornbuckle, till 1823, when he took the College living of Lilley in Hertfordshire, and married. He was very highly appreciated by his pupils as a lecturer, and not less as a friend and adviser. He resided at Lilley till failing health obliged him to seek change of climate at Ramsgate. After some years he returned to Lilley, and resided there for thirteen years: but he was obliged again to leave it in 1852, and resided at Ramsgate ever after. He never held any other preferment than his living, except a prebend at Wells, little more than honorary. He was a Fellow of the Royal Society, and of the Antiquarian Society, and a member of the Royal Society of Literature. He published a collection of Geometrical Problems, with an Appendix on Plane Trigonometry, a Treatise on Hydrostatics, Mechanical Problems, Problems in the different branches of Philosophy, and Algebraical Problems, better known as *Bland's Equations*, which have exercised the ingenuity of many a young mathematician. This last publication passed through many editions. A translation of it was published at Halle so recently as 1857. He drew up also Annotations on the Historical Books of the New Testament, but did not proceed with the publication of them beyond the Gospels of St. Matthew and St. Mark. His vigour of mind and keen interest in everything that passed, and particularly in all that affected his University and his College, he retained to the end of his life. He died of old age, without disease and without suffering, on Dec. 27, 1867, at the age of 81 years.

James John Downes, Esq., was born of humble parentage, on October 18, 1790. With indomitable energy he succeeded in qualifying himself for the position of mathematical tutor and lecturer on science. Among his pupils were several who afterwards obtained considerable reputation as mathematicians, while his originality of thought and skill in demonstration procured for him celebrity as a lecturer. In 1832 he was elected, after a strict examination, from upwards of thirty candidates, to fill the office of Actuary to the Economic Life Assurance Society. He performed the duties of this office with much ability and zeal for

a period of thirty years, when he retired into private life, carrying with him the esteem and respect of all with whom he had been officially associated. He died on November 12, 1867, beloved and respected by a wide circle of friends. He was a Member of the old Mathematical Society, and for some time officiated as Secretary. He published a small Handbook of Algebra, which is now out of print. He became a Fellow of our Society in 1837, and took an active part in the transfer of the old Mathematical Society and its valuable library to the Royal Astronomical Society.

CHARLES HOWELL, Esq., died at Hove, near Brighton, on December 8th, 1867, aged 84 years. He was elected a Fellow of our Society in 1857. He inherited from his father an ample fortune and devoted his early life, with much zeal, to nautical and agricultural pursuits. He was always attached to the use of the telescope, but it was not till he was far advanced in life that he built an observatory, furnished with excellent instruments, at Hove.

Mr. Howell's astronomical observations were chiefly of planets and of double stars. When by reason of advancing years he had become unfitted to employ himself in his observatory, he generously opened it to the unrestricted use of his numerous friends, and also for the purposes of education, in the hope thereby to enkindle in youthful minds a love of that science which he so ardently admired.

One of his last acts was to erect upon a valuable piece of ground in the centre of Brighton a range of almshouses which he has bequeathed for the use of the poor of that town. He died universally respected, and the poor deplore the loss of a truly benevolent and tender-hearted man.

Mr. WILLIAM BROOKE was born at Burnham Market, in Norfolk, on August 1st, 1795. His education at the outset was such as in remote provincial towns in those days was the only one accessible to the middle classes. But he was from his earliest years studious, and qualified himself to enter a private school kept by a Mr. Shrimshire, the Incumbent of North Creek, where he devoted himself to classical reading with so much assiduity as in a large degree to make up for his want of a public-school training. About the year 1820 he opened a school at Norwich, which he continued until age made it needful for him to retire from an occupation in which he had been engaged with much honour and a fair share of success for about forty-five years. Not a few of his pupils have acknowledged with gratitude the benefit they derived from his lectures on Experimental Science. This was before the appointment of Professor Sedgwick as Canon of the Cathedral, and the elevation of Bishop Stanley to the See of Norwich. These events greatly stimulated the scientific activity of the city, and Mr. Brooke was soon found in the front

ranks of a considerable and energetic band of inquirers and observers,—a position which he maintained to the end of his life. His meteorological observations were commenced before 1830; the records he kept and supplied to the local papers and to scientific journals. Mr. Brooke was elected a Fellow of our Society in 1849. In 1850 he joined the Meteorological Society. He died upon his natal day in 1867, aged 72 years, leaving behind him, in a wide circle of friends, the memory of a blameless and well-spent life.

Proceedings of various Observatories.

Royal Observatory, Greenwich.

The work of the past year has been of the usual character: comprising observations of the Sun, Moon, and principal planets, at every opportunity on the meridian; observations of the Moon with the Altazimuth extended as near conjunction as possible; and continuous observation of the principal stars.

The re-observation of Bradley's Stars contained in Bessel's *Fundamenta* has been completed, and it is intended to incorporate in a catalogue the results of the star-observations from 1861 to 1867 inclusive.

For the reduction of the Observations in 1868, the refractions will be computed with the mean refractions of Bessel's *Fundamenta* diminished in the proportion of

$$0{\cdot}99797 : 1$$

combined with the meteorological corrections of the *Tabulæ Regiomontanæ*. The colatitude adopted is $38^\circ\ 31'\ 21''{\cdot}60$. These changes have been made on the authority of Mr. Stone's paper in the *Monthly Notices* for Dec. 13th.

The piercing of the central cube of the Transit-Circle to allow of the adjustment of the wires of the collimating telescopes without raising the Transit-Circle has been followed by a change in sign of the astronomical flexure of the telescope. It has been found that the sign of the law of discordance between the direct and reflexion observations has changed, in 1866, with the change of sign in the astronomical flexure of the telescope; the resulting value of the colatitude is in satisfactory agreement with values previously obtained. It is probable that this will throw considerable light upon the origin of the discordances between the observations of stars in zenith distance directly and by reflexion at the surface of quicksilver.

The middle room of the Great Equatorial Dome has been

rendered fire-proof and will be used as a room for the deposit and trial of chronometers.

The greater part of the volume for 1866 has been passed through the press, and the reductions of the Observations for 1867 are complete and the results nearly ready for the printer.

Royal Observatory, Edinburgh.

The work performed here during the past year has not materially deviated from the usual Star Observations with the Transit Instrument and Mural Circle; public time-signals, with electric controlled clock superintendence; and the computations of meteorological observations from fifty-five observing stations of the Scottish Meteorological Society, the results being printed and published monthly or quarterly by the Registrar-General of Births, Deaths, &c. in Scotland. None of the additional accommodation so urgently required for the performance of this work has yet been supplied; and there is now a negotiation in progress for giving to the Royal Observatory, Edinburgh, the observations of seventeen more meteorological stations to compute every month, making seventy-two of such stations in all.

Radcliffe Observatory.

The subjects of observation at the Radcliffe Observatory, Oxford, were essentially the same for the past year as for those immediately preceding. The star-list includes the stars necessary for the completion of the re-observation of those which require it in the Catalogue of the British Association, and stars between the sixth and eighth magnitudes, lying chiefly between 50° and 70° of North Polar Distance, selected from various Catalogues. The Sun, as in former years, has been observed whenever it has been practicable, though the state of the sky has been, on the whole, nearly as bad as in the year 1866. The Moon has been observed in each lunation till the first transit (inclusive) after opposition; and *Mercury* and *Mars* whenever it has been practicable. The number of stars observed generally in both elements in 1867 is 1453; while, of the Sun, 92 observations have been made, of the Moon 56 observations, of *Mercury* 34, and of *Mars* 17 observations. The whole number of transits amounts to 2472, and of North Polar Distances to 2314. The number of good evenings for observation was, as in the year 1866, small.

The heliometer has been employed by Mr. Main, as in preceding years, for the observation of double stars. In connexion with this instrument it may be mentioned that, after a little correspondence with Mr. Merz, the maker of the object-glass, Mr. Main succeeded in separating the crown and flint lenses of the

segments of the object-glass, and, after cleaning their inner surfaces carefully, in fastening them together again, without detriment to the goodness of the images. Some additional transits of circumpolar stars were taken in the autumn, during some hot weather, for the re-determination of the value of the screw, by which it appears that that which has been in use for several years is sensibly accurate.

The reductions of the astronomical observations have been kept up with the same rigour as in the preceding years. The transits were perfectly reduced and ready for transcription into the ledgers, at the close of the year, and the North Polar Distances are now nearly completed. As in former years this has entailed very heavy personal labours on the Director.

The beginning of the solar eclipse of 1867, March 5–6, was well observed by three observers; the observation of the termination was prevented by clouds. A few observations of occultations of stars have also been made.

The printing of the Astronomical Results of observations for 1865 has been completed for some time, and copies were sent to a few of the chief astronomers in Great Britain; the printing of the Astronomical Results for 1866 is proceeding steadily.

The Meteorological reductions are, as in the preceding years, considerably in arrear, those for 1865 being not nearly completed. Their utility is, however, such, that the Director is unwilling to give up, for the present, at least, any of the discussions which have been carried out in former years.

Recently Mr. Baxendell has made some interesting deductions from the observations of solar radiation, by which it appears extremely probable that there is a periodicity of solar radiation synchronizing with the periodicity of the solar spots. Mr. Baxendell's discussions will at least give a value to observations of solar radiation which did not appear to belong to them before, and probably induce private observers to bestow greater care and attention on them.

In addition to the ordinary labours of the Observatory which have been detailed, a great deal of work has been done during the past year towards the compilation of the *Second Radcliffe Catalogue of Stars*. This is now in a very forward state. The results for the different years have been all combined in one catalogue, and reduced to the proposed epoch 1860; and the annual precessions and secular variations for that epoch have been computed. The Catalogue itself has been formed, containing very nearly 2400 stars (observed between 1855 and 1861, both inclusive), and the precessions and secular variations are transcribed into it. Very little remains to be done, but the combination of the observations in the different years, and the application of the corrections which may be considered necessary, as the result of the discussions which are connected with the work. It is expected that the Catalogue will be printed and published in the course of the present year.

Cambridge Observatory.

In addition to the ordinary transit and circle observations, the accurate determination of the places of those stars, selected from Oeltzen's List, in which the comparison of Lalande and Argelander seems to indicate large proper motion, has been constantly kept in view. These observations are now all but completed, and great progress has been made in the reductions. The true apparent right ascensions are obtained to May, 1867, and the true North Polar distances to the end of 1866. The reductions to the mean place for the beginning of the year are calculated to the end of 1866.

The equations of condition from occultations of fixed stars by the Moon, are calculated to the end of 1866, and equatorial observations of Comets are nearly all reduced.

The copy for the press is in progress, and will very shortly be in a sufficiently advanced state to be put into the hands of the printer.

The velocity of the wind has been measured by the Robinson's anemometer, which has worked satisfactorily, and a new and very sensitive vane has been erected.

All the meteorological observations have been regularly taken at the hours of 9 A.M., and 3 P.M., and more frequently in heavy storms.

A watch was kept for the November meteors, but the night was unfavourable, and very few were observed.

A small universal instrument, of beautiful workmanship, by Ertel of Munich, the property of the late Mr. Cooper, of Markree, has been secured for this Observatory.

Mr. Simms has made great progress in the construction of a new meridian circle for this Observatory, which is to be erected in the place of the present transit instrument. The circle is three feet in diameter, and the telescope is eight inches in aperture, and about nine feet in focal length. An excellent object-glass by Mr. Cooke, which has been already thoroughly tested by Mr. Dawes, has been purchased for it. The cost of the instrument is to be defrayed out of the Special Fund presented to the University by Miss Sheepshanks for the benefit of the Observatory.

The New Liverpool Observatory, Bidston, Birkenhead.

During the early part of last year the difference of longitude between the old Observatory on the east and the new Observatory on the west side of the Mersey, was found by the transmission of sixty chronometers to be $17^{s}\cdot04$. From this determination the longitude of the new Observatory is $12^{m}\ 17^{s}\cdot15$ West of Greenwich. In remounting the transit instrument of five feet focal length and four inches aperture, provision has been made for

using it either in the meridian or in the prime vertical. From five transits of *β Draconis*, four of *γ Draconis*, and one of *α Cygni*, each of them over the east and west prime verticals, the latitude is 53° 24′ 3″·8 N. or 44″·0 South of the old Observatory. By ten simultaneous readings of barometers at the two stations the height of the cistern of the standard at the new Observatory is 212 feet above the mean level of the sea, and 175 feet higher than it was at the old Observatory. The mean temperature for the year is 1°·4 lower at the new than at the old Observatory, as obtained from simultaneous daily readings of thermometers at the two stations during two years. The equatorial of twelve feet focal length and eight and a half inches aperture has been re-erected by Messrs. Troughton and Simms, under a dome of twenty feet diameter. The old transit-clock is placed in a cellar, twenty-four feet below the ground-floor of the building, and clocks controlled by it are placed in the transit and equatorial rooms. A new clock and spring-governor chronograph, made by Messrs. Bond and Son, of Boston, U.S., have recently been erected in a room contiguous to the transit and equatorial rooms. A clock regulated to Greenwich mean time, placed in the chronometer-room, controls one clock in the deep underground cellar, and another on the margin of the river near the Birkenhead Landing-stage; the latter controlled seconds clock, the face of which is exposed to public view, fires a time-gun daily at 1 P.M. An observer in the chronometer-room, within hearing of the beat of the normal clock, never fails to see the flash of the gun on a clear day, and in foggy weather, when the flash cannot be seen, the sound is heard at twelve seconds after 1 P.M. within a small fraction of a second. This mode of communicating time to the port and towns of Liverpool and Birkenhead is already very highly appreciated. The contact springs for the transmission of galvanic currents applied by Messrs. Ritchie and Son, of Edinburgh, to the sidereal and mean time clocks have not affected the regularity of their performance; the rates of both clocks have been much more uniform than they were at the old Observatory; but, in all probability, this is mainly due to their being placed in rooms in which the change of temperature during the year is very small. At the old Observatory, chronometers could only be tested during six or seven months of the year through the range of temperature to which merchant ships are generally exposed; in the new Observatory, during the past twelve months, the chronometers have been exposed on alternate weeks to the temperatures of 55°, 70°, 85°, 70°, and 55°, in regular succession throughout the year, so that in five weeks a chronometer can now be tested efficiently at any time of the year. The Observatory will in a short time be supplied with the means of testing various other nautical instruments in addition to chronometers.

Glasgow Observatory.

At the Glasgow Observatory the astronomical observations during the past year have been similar in character to those of previous years. The Transit Circle has been regularly employed in the observation of a select number of stars chiefly comprised between the fifth and eighth magnitudes. The Ochtertyre Equatorial continues to be used on every available occasion for the measurement of double stars. Correct time is transmitted to the City and Port of Glasgow, as in former years, by means of Jones's well-tried invention of the controlling of clocks by electricity.

The meteorological operations at the Observatory have acquired an important extension since the date of the last Report of the Council. It is generally known that the Board of Trade has recently assigned the superintendence of the meteorological operations of that department to a Committee of men of science, at the head of which is the President of the Royal Society, and that, among other recommendations of the Committee, has been the establishment of a definite number of stations distributed over the British Isles, furnished with self-recording instruments for ascertaining the continuous variations of the weather, and more especially for obtaining an exact determination of the facts connected with the occurrence of storms.

The Glasgow Observatory having been one of the stations nominated for this purpose, has been recently furnished with a complete system of self-recording instruments, the operations with which commenced on January 1 of the present year. It is hardly necessary to state that the Government has undertaken to defray the expenses connected with the fitting up of the instruments and the conducting of the subsequent operations.

Kew Observatory.

The regular progress of the work of the Kew Photoheliograph has somewhat suffered this year from two causes; one being the unfavourable state of the weather, which not only diminished considerably the opportunities for taking photograms, but also interfered with the usually excellent definition of the details in the Sun's appearance. The other cause was the interruption of the work from August 9 to September 9, in consequence of necessary repairs to the dome of the Observatory. There was therefore a falling off in the number of observed groups as compared with those registered by Hofrath Schwabe, by five groups, of which three must be accounted for by the difference of climate, while two groups have been observed in Dessau during the total interruption of the work at Kew. On the whole, there were 130 days of observation, on which 188 Sun-pictures were taken.

The work of reducing the observations, however, has not only been carried on with the greatest vigour, but former investigations have been extended on the basis of the Kew photograms, and steps have been taken to arrive at trustworthy results with reference to the important question of the influence of optical distortion on the observation-elements supplied by celestial photography generally and the Kew Photoheliograph specially.

The authors of the *Researches on Solar Physics*, Messrs. Warren De La Rue, Balfour Stewart, and Benjamin Loewy, announce that the third series of these is completed, and will probably be ready for the printer in a few weeks. They give in this paper, to which about 100 pages of tables are added, the following information:—

1st. A full description of the methods employed in the measurement and reduction of solar photograms, for determining the heliographical longitude and latitude of Sun-spots, with the view of deducing from them the elements of rotation of the Sun and the inclination of the solar equator to the plane of the ecliptic; also the final results, giving the heliographical elements of all Sun-spots observed in 1862 and 1863. This part may in a measure be regarded as a continuation of Mr. Carrington's results.

2nd. The results of the area measurement of all Sun-spots observed in 1862 and 1863, forming a continuation of their results published in Series II. of the *Researches*, which were founded on Mr. Carrington's drawings.

3rd. An account of some preliminary experiments undertaken to determine the amount of optical distortion in the photograms obtained with the Kew Photoheliograph.

4th. An inquiry into the distribution of spots in latitude, extending their former researches, which had only the ecliptical longitude in view, and adducing additional evidence for attributing to the planet *Venus* a preponderant influence on solar activity.

The plan for the work of the present year comprises the continuation of the astronomical work and application of the results to a new determination of the solar elements; area measurements of all Hofrath Schwabe's Sun-pictures, for establishing a more trustworthy curve of periodicity; the extension of their researches into the physical phenomena on the Sun based on these results; a repetition of the investigations on the distortion of the photographic image with more refined methods; and, finally, hopes are entertained that regular observations of the heating and actinic effects of the Sun may be set on foot.

Lord Rosse's Observatory.

The most remarkable amongst the recent observations made at Birr Castle is the discovery in four nebulæ of a more or less marked spiral arrangement.

These nebulæ are indicated by the following numbers in Sir John Herschel's General Catalogue: —

$\left.\begin{matrix}1519\\1520\end{matrix}\right\}$ Double Nebula, $\left.\begin{matrix}385\\386\end{matrix}\right\}$ Double Nebula, 1596, 2708

As the work on the Great Nebula in *Orion* was allowed to take precedence of other work, fewer observations on the nebulæ generally were made during the last year than would have been made under other circumstances; but from September 1866 to April 1867 more than 300 observations were recorded.

When the clock movement for the great reflector, which is now in progress, is finished, Lord Rosse intends to make further spectroscopic observations, and to try lunar photography, which was attempted, though with little success, some years ago, when the art was in a less perfect state.

Mr. De La Rue's Observatory at Cranford.

The past year has been remarkably unpropitious for the work carried on at this Observatory, for not only has the sky been overcast for a greater number of days than usual, but also the atmosphere has been very much disturbed on most occasions when astronomical photography could be attempted. This state of things has caused considerable perplexity, because two astronomers desirous of obtaining instruction in astronomical photography have had very considerable difficulty in obtaining the requisite opportunities for so doing. Mr. Le Sueur stayed at Cranford for some time during the month of February, and, by dint of great perseverance and watching for opportunities, was enabled to make lunar photographs on several occasions, and to thoroughly familiarise himself with the operations of astronomical photography. Notably on Feb. 22, Mr. Le Sueur, aided by Mr. Reynolds (photographic and mechanical assistant at Cranford), obtained a photograph of the Moon, of remarkable sharpness. Mr. Le Sueur, it is known, will have charge of the great Melbourne Telescope, which has been made by Mr. Grubb of Dublin, under the superintendence of the late Lord Rosse, Dr. Robinson, and Mr. De La Rue. Major Tennant, who will conduct the observations of the total solar eclipse in India on August 18th, which have been promoted by our Society, has also received instruction at Cranford, where he resided for some days on three occasions. On the first occasion, he was unable to obtain any opportunity for photography; in September, however, he was more fortunate, and took part on the 13th of that month in the photographic records of the lunar eclipse which occurred on that day. In December, Major Tennant was accompanied by the Sappers who had been detailed for the eclipse operations in India. The party consisted of Sergeant-Major Phillips and two Sappers. They thoroughly familiarised themselves with the working of the equatorial and the details of

the photographic operations performed with it; they also received instruction in enlarging photographs, and in etching them on glass, as detailed in Mr. De La Rue's Bakerian Lecture on the Solar Eclipse of 1860, published in the *Philosophical Transactions* for 1862. Major Tennant and his party therefore start with all the experience which has accrued from Mr. De La Rue's work in 1860–61; and if the weather prove propitious, it may fairly be expected that valuable records will be obtained by him and his staff.

Mr. De La Rue has received two silvered-glass mirrors from Mr. With; the first, although very good, was not considered by him to be equal to the metal mirrors figured by himself. The second, which has only been recently received, Mr. With believes to be very superior to the first made by him for the Cranford Observatory: but the weather has not yet permitted a fair testing of its performance.

Mr. De La Rue intends taking up again experiments in the figuring of specula; for which object his polishing machine has been removed from London to Cranford, where a small steam-engine has been erected. Hitherto, the polisher has been circular, and of nearly the same diameter as the speculum to be polished; it is evident, however, that a convex paraboloid of revolution can only fit exactly in a concave paraboloid so long as their axes coincide, which can only occur rarely during the operation of polishing. Three points, however, would touch a concave paraboloid in any part of the curve; although three mere points could not be used as a polisher, three small disks of pitch may be so employed, and it is assumed that by the use of a polisher so constructed, better figures may be obtained than heretofore:—it is in this direction that Mr. De La Rue's operations will be conducted.

Mr. Huggins' Observatory.

From the results of *spectroscopic* research at this Observatory during the past year, the following observations may be selected for mention.

The spectrum of *Mars* was carefully re-examined, but as this investigation has appeared in the *Notices* of the Society, it is not needful to give any details here.

On December 5, Mr. Huggins subjected the spectrum of the planet *Neptune* to a careful scrutiny, but was unable to detect any unusual lines of absorption which might account for the strongly marked blue colour of this planet. The faintness of its spectrum does not permit any great value to be attached to this negative result.

The comets visible during the year were too feeble in brightness to admit of the successful application of the prism. On two occasions, however, the spectrum of Comet II. was believed to be similar to that of Comet I. 1866.

The spectra of the stars η and μ *Geminorum* were examined in April. They were found to resemble very closely that of α *Orionis*, though there is apparently a somewhat different relative intensity of the lines.

During June, the spectrum of α *Herculis* was carefully examined, and the remarkably arranged groups of lines were remeasured. These observations agree with the measures and comparisons of the chemical elements of this star obtained in 1863.

Mira Ceti, which gives a spectrum apparently identical, or nearly so, with α *Orionis*, was examined when at its maximum brilliancy, and on several subsequent occasions, after it had commenced its downward curve. At the time the star was waning in brightness there was an appearance of greater intensity in several of the groups, but a continued series of observations is desirable, before any opinion is hazarded as to the cause of the variation in brightness which has procured for this object the title of "Wonderful." At Mr. Baxendell's request the variable R *Coronæ* was examined when at its maximum in the autumn, but without any successful result.

Mr. Huggins has confirmed the observations of MM. Wolf and Rayet so far as to the presence of bright lines in the three small stars described by them. He has not determined the number and positions of these lines.

During the year several attempts have been made to obtain a useful spectrum of the Milky Way. The spectra of the minute stars which are separately visible in his telescope were all continuous, but the spectra of unresolved portions could not be determined with certainty. There appears to be great probability, from their faintness, that these spectra are also continuous, for if they had consisted of a few bright lines, they would probably have been of manageable brightness.

The lunar object, *Linné*, has been observed and measured on every favourable opportunity during the year. The results obtained up to June are contained in the *Monthly Notices* for that month. Numerous observations have been obtained since, but Mr. Huggins is not prepared to make any further statement at present.

A few occasions of unusual atmospheric clearness were employed to re-examine and measure the bright granules of the solar surface. These views and measures confirm in every particular Mr. Huggins' description of these bodies in the *Notices* for May 1866.

Mr. Huggins has succeeded in constructing a new spectroscope, by which he is enabled to bring to bear on the celestial bodies an amount of dispersive power several times greater than has hitherto been applied to them. In this instrument the prisms employed have a dispersive power equal to about seven prisms of dense flint-glass of 60°. This instrument is found to be quite manageable even upon the nebulæ, and with it the bright

lines of the Great Nebula in *Orion* and of some other nebulæ have been compared directly with the bright lines of terrestrial elements.

Mr. Huggins intends to make use of this instrument in the continuation of his observations on the spectra of different parts of the Sun's surface, and of the solar spots. He has already insulated the spectrum of the umbra of a spot. These observations are in progress.

During the last two years Mr. Huggins has made numerous observations for the purpose of obtaining a view, if possible, of the red prominences seen during a solar eclipse. The invisibility of these objects at ordinary times is supposed to arise from the illumination of our atmosphere. If these bodies are gaseous, their spectra would consist of bright lines. With a powerful spectroscope the light reflected from our atmosphere near the Sun's edge would be greatly reduced in intensity by the dispersion of the prisms, while the bright lines of the prominences, if such be present, would remain, but little diminished in brilliancy. This principle has been carried out by various forms of prismatic apparatus, and also by other contrivances, but hitherto, however, without success.

The Progress of Astronomy during the past Year.

We have not, as on some former occasions, to record any remarkable and salient discoveries which will make the past year memorable in the annals of the science of Astronomy; but still, in the great activity which has been displayed by the cultivators of all its branches, we may see bright indications of sure and steady progress. Some of the labour of the past year has been spent in the form of preparation, the fruits of which, it is to be expected, will enrich the roll of discovery and research of the present and many succeeding years. Expeditions furnished with elaborate instruments have been originated and sent on their way to a distant country, for the purpose of learning as much as possible from the phenomena of a remarkable solar eclipse. Rapid progress has been made towards the completion of two magnificent telescopes, both of which will probably leave our shores during the present year.

We proceed to notice these and some other matters of prominent interest to the science of Astronomy.

The Total Solar Eclipse of August 17, 1868.

The present year will be signalised by a total solar eclipse of almost the greatest possible duration. As probably centuries may elapse before we shall have again an opportunity so excep-

tionably favourable for observing the peculiar phenomena which are only to be seen during a total eclipse of the Sun, it will be a source of gratification to the Fellows of the Society that two well-equipped expeditions have already proceeded to India for the purpose of making observations during the eclipse of August next.

One of these expeditions was originated by our Society.

Two letters of Major Tennant's, one published in the *Notices* of this Society for January, 1867, and the other forwarded to our Secretary early in February, but (owing to the Annual Meeting) only published in March, drew attention to the remarkable Total Eclipse of August 18, 1868. At their Meeting in March the Council accordingly appointed a Committee, consisting of the President, the Astronomer Royal, Mr. De La Rue, Maj.-Gen. Shortrede, and Col. Strange, to forward, if possible, the object of making observations during the very long obscuration of the Sun. It was decided that an application should be made to the India Office to bear the expenses of establishment and instrumental means, and that a silvered glass mirror should be mounted equatorially for photography, and that two telescopes kindly lent by the Astronomer Royal should be fitted for spectroscopic and polarization experiments. Estimates were submitted for the cost of instruments through the Astronomer Royal, and on the 15th July, sanction having been received for the cost, the instruments were ordered. Major Tennant proposed that he should be aided by Capt. Branfill, of the Great Trigonometrical Survey, and Lieut. Herschel, R.E., of the same department (who, however, has since undertaken a commission from the Royal Society), and that three men of the Royal Engineers should be trained to carry out the photographic operations. After some considerable delay, the expense was sanctioned, the Treasury having consented to bear half the amount. The delay had expended Major Tennant's leave of absence from India, and as much remained to be done, he was, on the matter being represented to the Secretary of State for India, detained at home on duty to superintend the preparations and the instruction of operators. Before proposing officially to employ men from the Royal Engineers, Major Tennant believed he had satisfactorily ascertained that there would be no difficulty as to their services being available; but an unexpected one arose, and it was fortunate that he was on the spot to remove them. He was cordially aided at the India Office by Mr. Arthur Hobhouse, who throughout has taken a personal interest in these observations, and assisted in every way to remove obstructions and avoid delays. On the 10th December Sergeant Phillips and Sappers Talbot and Conway, of the Royal Engineers, went to Cranford, where, by Mr. De La Rue's kindness, they went through the whole of the processes of taking the small negatives, enlarging, and etching them on glass. Major Tennant had gained some previous experience from several visits at Cranford since April last, and, though unfortunate generally in the weather, he had assisted at

photographing the lunar eclipse on Sept. 13. The proposed photographic operations differ from those formerly undertaken by Mr. De La Rue in Spain, where the Kew Photoheliograph was used, and the image of the Sun, in the focus of the object-glass, was enlarged by a suitable eye-piece before falling on the sensitive plate. It is now proposed to use a reflecting telescope (which ensures absolute identity of the actinic and visual foci) and to place the plate in the principal focus of the great speculum. The form is Newtonian, and the image being taken at the side of the tube allows room for a larger plate than could be placed in the centre of the tube; this is of great importance, as it is desirable to obtain as much of the corona as possible. The whole has been constructed by Mr. Browning, who has devoted to it a very great amount of time and care, with the advantage of the advice and experience of Mr. De La Rue. It is very satisfactory to know that the process of photographing celestial phenomena has been so completely mastered by Mr. De La Rue, that ordinary photographers can be taught in a few hours to use his apparatus with success.

In a paper printed in the Supplementary Number of our *Notices* Major Tennant, in view of his then immediate departure for India, described the apparatus which was in preparation. On Nov. 9, the Council were enabled, through the kindness of Mr. Howlett (who waved his claim on the instrument) to lend the Sheepshanks Telescope, No. 3, and by a grant from our funds to have it so modified as to enable this instrument to be used in the low latitude in which the eclipse is visible as total. Major Tennant, having thus an equatorial with clock-work motion, has transferred to it the spectroscope made by Mr. Simms, and has adapted the polarization apparatus made by Mr. Ladd to the telescope from Greenwich, which was equatorially mounted by Mr. Simms for the spectroscope, as described in the paper referred to. The facilities for observing have, of course, been thus greatly increased. In the arrangement of the spectroscopic and polarization apparatus, Major Tennant desires to acknowledge the aid he has received from the Astronomer Royal and our Secretary, Mr. Huggins.

The other expedition has been sent out by the Royal Society, and the necessary instruments provided out of the Parliamentary grant annually placed at the disposal of that Society.

The superintendent of this expedition, Lieut. John Herschel, R.E., an assistant in the Great Trigonometrical Survey, and a son of Sir John Herschel, has been instructed to confine his attention to observations of the spectra of the corona and red prominences, and to an examination of the light of these objects for polarization. He is provided with instruments suitable for these observations. The telescope for the spectrum observations has an aperture of five inches, and an equatorial mounting. It is furnished with a superior driving clock, the rate of which is maintained uniform by a form of pendulum-governor recently invented by Messrs.

Cooke and Sons, by whom the whole instrument was constructed. It is provided with a complete spectroscope constructed by Messrs. Simms.

For the observations for polarized light there is a second telescope of three inches aperture, furnished with two analyzers. The observer is instructed to use, first, a double-image prism, and a plate of quartz cut perpendicularly to the axis. If only a small amount of polarised light be present, it will be shown by the complimentary tints of the images. The second analyzer, consisting of a Nicol's prism and a compound plate of quartz, showing Savart's bands, may then possibly be employed with advantage to determine the position of the plane in which the light is polarized.

In addition to these instruments, four hand spectrum-telescopes of the form constructed by Mr. Huggins for the observation of meteors,* have been sent out for use by observers stationed at different places along the central line of the eclipse.

It will be, doubtless, of interest to our Society to know that Lieut. Herschel has been recommended to apply himself, as far as his other arrangements may permit, after his arrival in India, until the period of the eclipse, to the extremely important work of a prismatic examination of the brightest of the Southern Nebulæ. For these observations the instruments at his disposal are perfectly suitable.

Unless the weather should be unfavourable at both the stations selected by the two expeditions, we may confidently anticipate results of great value to our knowledge of solar physics from the carefully considered observations which are proposed to be made in August next.

This may be a suitable place to call attention to an observation of a red prominence made during the annular eclipse of March 6, 1867. Dr. Weiss, who accompanied an expedition into Dalmatia, where the eclipse was annular, has placed on record the following observation of Ensign Kiha, who was stationed about 2½ geographical miles north-west of Ragusa. He made use of a telescope of 2-inches aperture, furnished with an eye-piece magnifying 40 diameters. 14·4 minutes before the annulus was formed he saw a protuberance which, with some interruptions from clouds, he kept in view until 14·7 minutes after the formation of the ring. When first detected, the prominence was already a striking object, and it disappeared, not through excessive faintness, but in consequence of the passage of a cloud. Kiha described the object to be of the form of a small flame, and to have a brownish yellow colour. It was marked in the direction of its length by stripes of a deeper tint of the same colour. The observations of the protuberance show that it could not have had any connexion with the Moon.

* See "Proceedings, Royal Society," vol. xvi., p. 241.

It is certainly important that these phenomena should be looked for on every occasion which may possibly favour their visibility.

On the Possible Influence of the Tides on the Position of the Earth's Axis.

The question, so highly important under many aspects, of the possible effects during the past history of the Earth of the frictional action connected with the tides, has been carefully discussed by Mr. Stone, in reference to the possibility of the production by this action of a secular change in the position of the Earth's axis of rotation. Mr. Stone investigates this action upon two distinct hypotheses. He first takes the frictional action to be equivalent to a couple whose intensity is proportional to the existing angular velocity, and whose axis coincides with the instantaneous axis. Secondly, he supposes that the tidal action may be represented by a couple of resistance with its axis perpendicular to the plane of the ecliptic and proportional to the relative angular velocity of the Earth and Moon on this plane. The exceeding slowness of the resulting secular changes would appear to remove the tidal action from the direct causes to which we may look for those great secular changes of climate which geology has shown to have succeeded each other upon the surface of the Earth.

Star Catalogues.

The observations of stars made with the Meridian Circle of the Bonn Observatory from the year 1845 to the beginning of the year 1867, have been collected by Dr. Argelander into a catalogue, the epoch of which is 1855. This valuable Catalogue contains accurate places of most of the known variables. The total number of star places contained in the Catalogue is 33811.

Mr. Ellery, the Director of the Melbourne Observatory, has published his star observations made during the year 1863, 1864, and 1865. These observations are of great importance in the present dearth of materials from the Southern hemisphere. Mr. Ellery has most wisely extended his observations of Circumpolar Stars to considerable distances from the pole, and has also observed a large number of stars for comparison with the results of the Northern observatories.

Manuscript Star Charts.

During the past year the Society has become possessed of a very valuable series of MS. Star-charts by presentation from Sir John Herschel.

These charts contain the estimated magnitudes of stars visible to the naked eye in both hemispheres, and were made by Sir

John Herschel both at the Cape of Good Hope and in England. These charts have been strongly bound in volumes. They will be of great value in the case of any suspected changes of magnitude, and especially in the event of a supposed disappearance or outburst of a star.

Spectrum Analysis.

During the past year the most important addition which our science has received from the application of spectrum analysis to the heavens has been obtained at the Paris Observatory. After an extended examination of stellar spectra with the large silvered glass reflector belonging to that Observatory, MM. Wolf and Rayet at length discovered three stars, at no great angular distance from each other, which are distinguished by *bright* lines in their spectra.

These stars are, in Argelander's Catalogue (1850):—

Zone	+35°	8·5 mag.	R.A.	20h	4m	49·3s	δ	+35° 45·1
,,	+35	8 ,,	,,	20	6	27·3	δ	+35 46·1
,,	+36	8 ,,	,,	20	9	6·7	δ	+36 13·3

In the spectrum of the second of these stars, MM. Wolf and Rayet have observed four bright lines. The brightest of these lines occurs between F and G. The remaining three lines are seen in the part of the spectrum from F to D.

It may be well to suggest that these stars should be carefully watched for variability, as the presence of bright lines may possibly indicate physical conditions existing in these distant bodies, which are possibly of a less permanent character than are those of the stars which possess dark lines of absorption only in their spectra. It is satisfactory to know that Mr. Baxendell has made careful comparisons of these three stars with neighbouring stars, so that if any change of brightness should take place in any of them, it will be readily detected.

Comet II. 1867, has been examined by Mr. Huggins, who concludes, from a somewhat imperfect observation of this faint object, that this small Comet was, at the time of examination, similar in physical constitution to Comet I. 1866.

Mr. Huggins has communicated to the Society, in the *Notices* for March, the results of a further examination of the spectrum of *Mars*. In this paper he gives a more detailed account of the lines which show the existence of an atmosphere similar to that of the Earth, though probably not identical with it. Further, he states reasons for attributing the distinctive ruddy colour of this planet not to the absorptive properties of its atmosphere, but to some peculiarity of certain parts of its surface.

Father Secchi has collected in one memoir all the spectrum observations made at the Roman Observatory. The results of these observations have already been published from time to time in the *Comptes Rendus* and elsewhere. This memoir is printed in the *Volumi dell' Academia dei XL.*

The Great Nebula in Orion.

The discovery of the gaseous constitution of many of the Nebulæ, at the same time that it added to the mystery connected with these objects, gave us fresh hope of acquiring ultimately some knowledge of the relation which they hold to the other objects in the heavens. Changes in their appearance, sufficiently marked to be seen by us, and occurring within periods not so prolonged as to make us despair of being witnesses of them, were suggested to us as highly probable. In the northern hemisphere no nebula presents to an observer so large an amount of detailed structure as the Great Nebula in *Orion*. It will therefore be a source of much satisfaction to Astronomers that the results of the study of this object for many years by the late Lord Rosse are now made public by our fellow, the present Earl of Rosse. A large and exceedingly valuable map of the nebula accompanies his paper, which is printed in the *Philosophical Transactions of the Royal Society.*

The materials at our disposal for the study of this wonderful object have been further increased by the appearance of the valuable and laborious observations of the Great Nebula, and the measures of numerous stars scattered throughout it, which were left unpublished by the late Professor G. Bond. These researches have been carefully edited by Professor Safford, and they form volume V. of the *Annals of the Observatory of Harvard College.* The observations are accompanied by a very beautiful revised engraving of the Great Nebula from the drawings of Professor G. Bond.

D'Arrest's Catalogue of Nebulæ.

Our science has been enriched during the past year by the appearance at Copenhagen of an extensive Catalogue of the Nebulæ observed by Dr. D'Arrest, with the 11-inch refractor of the Observatory of that city, during the years from 1861 to 1867. The Catalogue contains 4800 separate observations of 1942 Nebulæ. Amongst the Nebulæ recorded there are about 390 which have been observed for the first time, or have not had their places determined previously with the accuracy necessary for their recognition. The value of this Catalogue is very greatly increased by numerous descriptions of the appearance of the objects observed, and micrometrical measures of such of them as admitted of this determination.

The Melbourne Reflector.

It will be source of much gratification to all who take an interest in our noble science that the present year will probably witness the erection at Melbourne, Australia, of a powerful telescope in some degree adequate to the exploration of the rich but hitherto very partially-explored regions of the southern heavens. The 4-foot reflector, now in Mr. Grubb's workshop, approaches completion, and according to Dr. Robinson's report, appears to be very successful in respect alike to its optical qualities and to the scarcely less important mechanical arrangements by means of which the observer may, without inconvenience or fatigue, direct and manipulate at his pleasure this magnificent instrument. The telescope is of the Cassegrain form of construction, and is mounted equatorially.

Dr. Robinson says, "The peculiar nature of the mounting brings the circles completely within reach of the observer's assistant; and the mechanical appliances for the motions in right ascension and polar distance are so perfect that we set the instrument on the faint objects which we were examining with great facility and rapidity. One man can reverse the telescope in a minute and a quarter; the quick motion in polar distance is far easier, and the slow one acts more like the tangent-screw of a circle than the mover of such a huge mass. The clock does its work with great precision, the objects remaining steady on the wire as long as I watched them; and there is an ingenious and new contrivance for suiting its speed to planets or the Moon."

The telescope is to be supplied with the necessary apparatus for photography and for spectroscopic investigation.

There still remains the important question as to the most convenient method of sheltering the instrument from rain, and especially from dust. A revolving roof, 46 feet in diameter, is at present suggested as the most expedient method.

Mr. Newall's Great Refractor.

By their successful completion of the bold undertaking to construct an achromatic object-glass, 25 inches in diameter, and 29 feet in focal length, Messrs. Cooke and Sons have done honour to our country, as well as performed a most important service for the science of Astronomy. They state that this magnificent telescope performs admirably, and that the character of the disks of stars seen in it are such as to show that the aberrations of this enormous glass have been properly corrected. The great weight of the two disks of glass forming the object-glass, which amounts to 146 lbs., has required a peculiar arrangement of levers to prevent flexure in the different positions of the telescope.

The equatorial mounting of the telescope is finished, and the expectation may be entertained, that, during the present year, it will reach Madeira, where it is to be placed under the care of Mr. Marth, who is already familiar with the use of large telescopes by the experience which he gained during his sojourn with Mr. Lassell at Malta.

A 7-inch transit-circle will complete this important astronomical establishment, which we shall owe to the munificence of our Fellow, Mr. Newall.

November Meteors.

The meteor shower of November 1867 was not well seen in Europe. The position of the radiant point was not favourable, and the sky was generally clouded. Enough, however, was seen to convince observers that a great display was in progress. The observations now coming in from the American Continent show that the shower of last November was but little inferior to that of 1866.

In the *Monthly Notices* for April will be found a discussion by Professor Adams, of the "Orbit of the November Meteors." Professor H. A. Newton, in his Memoirs, contained in Nos. 111 and 112 of the *American Journal of Science and Arts*, had discussed with great care the ancient records of November Showers, and shown that their principal features could be explained by supposing the meteoric matter to move in ellipses with periods of 180·0 days; 185·4 days; 354·6 days; 376·6 days, or 33·25 years. Professor Newton also determined the motion of the node of the orbit, to be about 29′ in 33·25 years. He suggested the possibility of determining which of the five periods, possible so far as the other facts were concerned, was the real period, by determining the disturbing action of the planets upon the orbit of the meteors. In this state the question was taken up by our Fellow, Professor Adams. He first determined the secular motion of the node, on the assumption that the period was 354·6 days, the period which Professor Newton considered the most probable. The motion of the node thus produced would have amounted only to 12′ in 33·25 years. The period of the meteoric matter could not, therefore, be 354·6 days. The periods 180·0, 185·4, and 376·6, proposed by Mr. Newton, would have given results less, or nearly equal to, that resulting from the period 354·6 days. Professor Adams, therefore, finally confined his attention to the period 33·25 years. With this period and a new determination of the other elements of the orbit, made from the observations of November, 1866, Professor Adams found the secular motion of the node in 33·25 years to be 28′; of which 20′ was due to the action of *Jupiter;* 7′ to the action of *Saturn;* and 1′ to the action of *Uranus.* The effects of the disturbing actions of the other planets were small. The close agreement of the theoretical value thus obtained by Professor Adams, with the observed value 29′,

is undoubtedly sufficient to prove that the period of the November meteors is 33·25 years. This result of Professor Adams' investigation is probably the most important contribution Physical Astronomy made during the year.

The very close agreement pointed out by Signor Schiaparelli, between the orbits of the August Meteors and Comet II. 1862, and his bold speculation as to the identity of cometic and meteoric matter has been followed up by the reference of Comet I. 1866, to the November stream. The agreement of the elements of the orbit of Comet I. 1866, and the November meteors appears to have been first pointed out by Mr. C. F. W. Peters.

Parallax of 34 *Groombridge.*

The few stars, the parallax of which has been determined with more or less accuracy, were first pointed out as favourable objects for such an investigation by the extraordinary observed amount of their proper motion. 61 *Cygni* is remarkable for an annual progressive displacement amongst its apparent neighbours by a motion exceeding 5″ per annum. The valuable star-catalogues of the Bonn Observatory show that a similar proper motion of large amount distinguish some other small and inconspicuous stars. In the northern heavens after the five stars—1830 *Groombridge*, 61 *Cygni*, *Lal.* 21185, *Lal.* 21258, and μ *Cassiopeiæ*—comes the star 34 *Groombridge*, 8.9 magnitude, which Krüger has shown to have an independent motion of 2″·84 yearly. The probable relative nearness to our system which this larger proper motion appeared to indicate induced Dr. Auwers to undertake the examination of the star for parallax. The method adopted by him was the chronographic registration of its Right Ascension in comparison with two neighbouring stars, one preceding it and one following it.

The observations on 79 nights extend during three years, and were made with the 6-foot Equatorial of the Observatory of Gotha. During the registration by the chronographic method the times of passage of 34 *Groombridge* and the two stars of reference across the 15 threads of the eye-piece, the telescope always remained unmoved in Right Ascension.

This carefully conducted investigation leads to a value of the parallax for the star, of the truth of which Dr. Auwers considers there cannot well be any doubt entertained.

If the stars of reference, which are 7 mag. and 8 mag. respectively, be supposed to have a mean parallax of 0″·015, with a mean error of ± 0″·009, the absolute parallax of 34 *Groombridge* will be

0″·307, mean error ± 0″·0376, probable error 0″·0254.

This value will place the star under investigation at a distance from us = 672,000 radii of the Earth's orbit, with a probable

error of 56,000 radii. The light emitted by the star would require 10·6 years to reach the Earth.

There is another star of the 10·5 magnitude within 40″, which appears to be in physical connection with 34 *Groombridge*.

The probable relative nearness of this faint star, as shown by the investigation of Dr. Auwers, gives additional weight to the arguments which have been stated against the assumption that the apparent brightness of the stars may be received as an indication of their distance from our system.

Asteroids and Comets.

Four Asteroids have been discovered during the past year, viz.: (92) *Undina*, by Dr. C. H. F. Peters, at Hamilton College, U. S., on 1867, July 7; (93) and (94), by J. C. Watson, at Ann Arbor Observatory, U. S., on 1867, Aug. 24 and Sept. 6, respectively; and (95) *Arethusa*, by Dr. Luther, at Bilk, on Nov. 23.

Three Comets have been discovered during the past year.

Comet I. 1867, by Stéphan, at Marseilles, on January 22. The discovery of this Comet was mentioned in the last Report.

Comet II. 1867, by Tempel, at Marseilles, on April 3.

Comet III. 1867, by Bäker, a clockmaker, of Nauen, on the evening of Sept. 26, and four hours afterwards by Dr. Winnecke.

Our Fellows will, we are sure, receive with great satisfaction this proof of Dr. Winnecke's restoration to health, and return to the scene of his former labours.

Mean Distance of the Sun from the Earth.

In the *Monthly Notices* for May, 1867, will be found a short abstract of a paper by Mr. Stone, containing a numerical determination of the parallactic inequality in the Moon's motion, and a deduction of the corresponding value of the Solar Parallax. The coefficient of the parallactic inequality is found to be 125″·36 and the value of the solar parallax, 8″·85. A paper on this subject by Mr. Newcomb forms Appendix II. to the *Washington Observations* for 1865, published in 1867. This paper contains a careful re-discussion of the observations of *Mars* made near the Opposition of 1862, at the Observatories of Albany, Greenwich, Pulkova, Washington, Cape of Good Hope, Santiago, and Williamstown. The value of the solar parallax deduced by Mr. Newcomb is 8″·855. This value is smaller than 8″·964, deduced by Dr. Winnecke from a comparison of the Pulkova and Cape Observatories, and also smaller than 8″·943, the value found by Mr. Stone from a discussion of the Greenwich observations and corresponding observations at the Cape of Good Hope and Williamstown. There is unfortunately some objection to the use of the Santiago observations in an entire ignorance of the inclination of

the wire. It may be mentioned that the Santiago observations had previously been compared by Mr. Ferguson with twelve corresponding Washington and fifteen corresponding Albany observations of *Mars*. The results thus found for the solar parallax were respectively $8''\cdot834$ and $8''\cdot611$.

Binary Star Σ 3062.

The orbit of this close and interesting binary star has been calculated with much apparent care by M. Fuss. Since this star was discovered by Sir Wm. Herschel in 1782, it has performed more than three-fourths of a revolution. Its closest approximation took place about 1835, when it was $0''\cdot4\pm$. The results of M. Fuss's calculations give the following elements of its apparent orbit:—

Semi-major axis	$1''\cdot287$
Semi-minor axis	0·999
Distance of principal star from centre of ellipse ..	0·416
Position-angle of the line joining both points ..	$-36°\ 48'$
Position-angle of line of apsides	$+46\ \ 18$

Rotation-Period of Mars.

By means of a careful comparison of the views of *Mars*, by different observers from Hooke in 1666 to Mr. Browning in 1867, Mr. Proctor concludes that

$$88642^{s}\cdot735 \quad \text{or} \quad 24^{h}\ 37^{m}\ 22^{s}\cdot735$$

may be accepted as very nearly the true value of the rotation-period of that planet.

Comet III. 1860.

The numerous exact observations which were made of this Comet in the summer of 1860, appeared to Dr. Auwers to furnish materials for a determination of its path more accurately than is usually possible in the case of these remarkable bodies.

The observations of the Comet at many Northern observatories, from June 18th to July 24th, were followed by observations made in the Southern Hemisphere, from July 8th to Oct. 18th, when it was seen for the last time at the Cape of Good Hope. During the four months of its visibility it had passed through an arc of 96°, as seen from the Sun. The whole of the curve, however, belonged to the same side of its path, as it had already passed its perihelion at the time of its discovery. Dr. Auwers was aided in his research by M. Sievers, who made a new determination of the places of 110 of the stars of comparison.

Dr. Auwers gives several determinations which differ but

very slightly from each other. He appears to consider as most trustworthy those in which the more homogeneous materials only are employed. The following elements are those which result from his fourth determination:—

$$
\begin{aligned}
T &= \text{June } 16{\cdot}061003 \text{ Gr.} \\
\log q &= 9{\cdot}4666978 \\
\varpi &= 161^{\circ}\ 32'\ 27''{\cdot}68 \\
\Omega &= 84\ \ 40\ \ 32{\cdot}08 \\
i &= 79\ \ 19\ \ 25{\cdot}47
\end{aligned}
$$

Motion Direct.

Communications to the Society from February 1867 *to February* 1868.

1867.

Mar. 8. On the Planet *Mars*. Mr. Joynson.

On the compatibility of the retrograde motion of the November Meteors with the Nebular Theory. Mr. Hippisley.

On an Astronomical presentiment of Immanuel Kant relative to the constancy of the Earth's Sidereal Rotation on its Axis. Mr. Wackerbarth.

On the measurement of the Apparent Discs of Stars. Mr. Knott.

Notice explanatory of a series of MS. Charts containing the estimated Magnitudes of Stars visible to the Naked Eye in both Hemispheres. Sir J. Herschel.

Observations of a Meteoric Shower at Bishnagur, November 14, 1866. Mr. Masters.

Observations of *Iris* and *Vesta* at Dunsink. Dr. Brünnow.

Observations of the Eclipse of March 5, 1867. Mr. Brothers.

On the estimation of Star Colours. Mr. Kincaid.

On the Spectrum of *Mars*, with remarks on the Colour of the Planet. Mr. Huggins.

Determination of the coefficient of parallactic inequality and a deduction of the Sun's Horizontal Equatorial Parallax from the Greenwich Lunar Observations, 1848–60. Mr. Stone.

Observations of the Solar Eclipse, March 6, 1867. Capt. Noble.

Observations of the Meteoric Shower in Australia. Mr. Duone.

On the disturbance of the Solar Photosphere by Planets. M. Hoek.

A perfect form of Object-glass, deduced from a critical analysis of the Secondary Spectrum. Mr. Dawson.

On the Solar Eclipse of 1868, August. Major Tennant.

Observations of Solar Eclipse, March 5, 1867. Mr. Lassell.

Observations of Solar Eclipse, March 5, 1867. Mr. Prince.

Meteoric Shower of November 1866. Mr. Kincaid.

Meteoric Shower of November 1866, log of ship *Evangeline*. Capt. Wood.

Solar Eclipse, March 6, 1867. Lord Wrottesley.

ril 12. Errors in Tables of Logarithms. Mr. Wackerbarth.

Observations of Solar Eclipse, March 5, 1867. Prof. C. P. Smyth.

On the Mass of the Moon, deduced from the Mean Range of Spring and Neap Tides at Dover. Mr. Finlayson.

Errata in his Logarithmic Tables of 1849. Major-Gen. Shortrede.

On the distribution of Nebulæ in Space. Mr. Cleveland Abbe.

Eclipse of the Sun, 1867, March 5, and Occultation of a Star by the Moon, 1867, January 16. The Astronomer Royal.

Errata in two Papers of his. The Astronomer Royal.

Motion of the Solar System in Space. Mr. Stone.

Note on the Calculation of the Sun's Parallax from the Lunar Theory by P. A. Hansen. Mr. Stone.

Determination of a slightly corrected Value of the Solar Parallax, from the data of Le Verrier's Solar Tables. Mr. Stone.

On the Heat attained by the Moon. Mr. Harrison.

Catalogue of New Stars. Mr. Chambers.

y 10. Additional Remarks on the Solar Eclipse of March 5, 1867. Mr. Brothers.

Observations of Comet II. 1867. Mr. Talmage.

Occultation of *Mercury* by the Moon, May 1, 1867. Capt. Noble.

ne 14. On the connection between Comets and Meteors. Mr. Stoney.

Meteors observed 13–14 November, 1866. Mr. Burton.

On the earliest traces of good Practical Astronomy. Prof. C. P. Smyth.

On certain appearances of the Telescopic Images of Stars, described by Rev. W. R. Dawes. The Astronomer Royal.

Determination of the Longitude of the Sydney Observatory, from Observations of the Moon and Moon-culminating Stars made in 1859–60. Mr. Stone.

Approximate relative Dimensions of the Asteroids. Mr. Stone.
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On the alleged change of focus requisite in observing Stars widely separated in altitude. Capt. Noble.
Measures of diameters of first bright ring of Star disk. Mr. Knott.
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Nov. 8. On the Transits of *Jupiter's* Satellites and the Lunar Eclipse. Mr. Weston.
Eclipses and Transits of *Jupiter's* Satellites. Mr. Weston.
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On *Jupiter* without Satellites exterior to his disk. Mr. Burr.
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Jupiter without a visible Satellite. Rev. W. R. Dawes.
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On the Newton-Pascal Controversy. Prof. Grant.
Determination of the Longitude of the Kingston Observatory. Mr. Williamson.
On some newly-discovered Stars near *α Lyræ*. Mr. Buckingham.

Dec. 13. On the November Meteors, 1867. Mr. E. J. Lowe.
Ditto ditto Mr. Kirkwood.
New Laws of Planetary and Satellitary Motions. Mr. Glennie.
Rotation of *Mars*. Mr. Proctor.
On the Colours of Stars. Mr. Browning.
On the Solar Eclipse of 1868, August 17–18. The Astronomer Royal.

Some remarks on the Value of the Solar Parallax. Mr. Stone.

On Bessel's Mean Refractions. Mr. Stone.

Attempts to facilitate the Prediction of Occultations and Eclipses. Mr. Penrose.

1868.

Jan. 10. *Jupiter* and his Satellites. Mr. Barneby.

Meteoric Shower, Nov. 14, 1867. Lieut. Chimmo.

Ditto ditto. Mr. G.W. H. Maclear.

Ditto ditto, observed at Nassau, Bahamas. Mr. Lawson.

On the Variable Star T *Serpentis*. Mr. Baxendell.

On a contrivance for Reducing the Angular Velocity of Meteors. Mr. Browning.

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On the Minimum of U *Geminorum*. Mr. Knott.

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Discovery of a minute Companion to γ *Equulei*. Mr. Knott.

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ADDRESS

Delivered by the President, the Rev. Charles Pritchard, on Presenting the Gold Medal of the Society to M. Leverrier.

The Society's Medal, at all times a subject of deep solicitude to the Council, has this year been awarded to M. Leverrier for his Solar and Planetary Tables. A brief inspection of the earlier pages of the *Nautical Almanac* will be quite sufficient to explain the desire which has long been felt by successive Councils publicly to testify to the distinguished Director of the Imperial Observatory of Paris, their deep sense of the services which he has rendered to astronomical science by the publication of Tables which in this country have superseded all others for the computation of the places of *Mercury, Venus, the Earth,* and *Mars*, in their respective orbits.

Probably few subjects connected with physical inquiries, on a first and distant view of them, present an aspect more unattractive than the contemplation or discussion of long and complicated Planetary Tables. To the mind unprepared, to the eye not specially educated, such Tables must necessarily appear little more than a repulsive mass of symbols, or a maze of numerical expressions strung together, no doubt, after some recondite, but to such a mind, assuredly, unintelligible scheme.

In addressing, however, the members of a learned Society such as ours, it may properly be assumed that the great majority

have reaped the high reward of a diligent prosecution of the noblest of the sciences, and that to their minds, what seems to others a cheerless array of figures, becomes animated with intelligence, and illuminated with the light of thought. The well-instructed geologist, in the fragment of a rock, reads the history of the formation of an ancient continent; from a fossil bone he knows how, by his unerring curious art, to picture to himself the form, and the dimensions, and the habits of a creature whose span of existence, and all its concomitant relations, were allotted to it in ages long since passed away. In like manner the astronomer, in the long columns of the Tables before him, observes not a mere series of abstract numbers, but he traces therein the very pulsations of the planets as they are impelled hither and thither by the approach or recession of the celestial masses forming the system of bodies amidst which they move. He recognises therein the play and the interactions of the chief forces of the Universe. Nor is this all; for ever and anon these apparently lifeless symbols recall to his memory some high achievement of the genius of man; he reads upon the page the imperishable epitaphs of Newton or Bradley, or Lagrange, or Laplace, or Bessel; or he is invited to rejoice in the light of men worthy to be their successors and still spared to ourselves, such as Hansen, or Airy, or Adams, with Leverrier and Delaunay, and a host of others of no inferior fame.

You are aware that a series of modern tables intended to represent the motions of a planet consists, generically, of two parts; the former part representing the place which the planet would have occupied at any specified moment had its motion been calculated for a certain hypothetical but definite ellipse with the Sun in its focus; and the latter part furnishing the amount of deviation caused by the disturbing action of the other celestial bodies. The form, dimensions, and position of the afore-mentioned ellipse, are determined, with the exception of certain secular variations, for the most part by considerations depending on geometry and observation alone; and herein there come largely into play the perfection of the instrument and the skill of the observer. The deviations from this provisional or hypothetical orbit, arising from the perturbations of the other celestial masses, are calculated on the principles of the Newtonian theory as extended by the later investigations of Lagrange and Laplace. These disturbances or deviations from this elliptical motion depend on the masses, distances, and configurations of the planets, or of the elements of their orbits, and are never presumed to be exactly known: they are approximations only, representing more or less the truth of the case, though generally, as we shall see, to a wonderful, and it might be said, unhoped-for degree of precision. It is for very important additions made towards the exactness of these approximations, and for the convenient methods in which they are prepared and arranged for further improvements by future physical astronomers, that we are this day

anxious to express our gratitude to the eminent Director of the Paris Observatory.

When M. Leverrier, in the year 1854, and seven years after the discovery of *Neptune*, was called to the direction of the Imperial Observatory, he found it in a condition of lamentable deficiency, to which we should not here have ventured to allude had not that able astronomer himself pathetically described his disappointment in the Annals of his own publication. Moreover, we shall find in the sequel that this very circumstance soon becomes associated with his fame. He states that, in the imperial city, long adorned by the genius of Laplace, and by the unrivalled analysis of Lagrange, until the year 1800 there was no transit instrument of any description existing within the walls of the Observatory.* It is still more incredible that, up to the year 1828, the instrument then provided was inferior to that with which Bradley had verified his immortal discoveries, and had laid the foundation of modern astronomy some seventy years before. Moreover, at the very time when the great Transit Circle at Greenwich was in full operation, there was not a telescope within the Paris Observatory admitting as much as the fourth part of the light which was then brought to the focus of the noble instrument at the disposal of the English Astronomer Royal, and constructed after the model proposed by himself. English politicians, and even English philosophers, have a peculiar, but well-known tendency to express dissatisfaction at their own national or official arrangements. If among the members of our Society there should chance to be any who are disposed to indulge in this luxury of self-dispraise, I am afraid that our distinguished Medallist has deprived them of, at least, one source of this gratification by his candid statement, that "The Paris Observatory, excepting at the epoch of Dominique Cassini, had always been half a century in arrear of Greenwich, so far as its instrumental resources were concerned."

All this unfortunate deficiency M. Leverrier, immediately upon his appointment, set himself diligently to repair, with the noble ambition of entering, as he says, "upon a pacific contest with other nations, for a place in the foremost rank of astronomical fame, and for the recovery and maintenance of the scientific renown of France."† The present reputation of the Imperial Observatory, and the high and undoubted estimation of its Annals by foreign astronomers, cannot fail to furnish, even to the laudable ambition of its Director, a satisfactory proof that these hopes have been fully realised.

At the time of the establishment of the Paris Observatory in its modern efficiency, M. Leverrier found that, either by mutual arrangement or by prescription, the other great National Observatories had appropriated each to itself a special line of astronomical observation. Greenwich, in obedience to the wise directions of a

* *Annales de l'Observatoire Impérial*, vol. i. † *Ib.*

Royal Warrant, had become unrivalled for its accurate and persistent observations of the Moon, and of such other phenomena as might contribute to the furtherance and security of the Art of Navigation. Pulkowa, under the direction of the elder Struve, had long gained a well-merited reputation for the advance which had there been made in Sidereal Astronomy. M. Leverrier entered upon his career of a friendly rivalry with these noble institutions by at once assuming for himself the unappropriated but laborious task of recomputing the tabular places of the Planets, on the basis of the analysis of Laplace, with the utmost attainable rigour of exactness, and of then comparing these theoretical places with actual observation. The discordances, however small they might be, between the computed and the observed places, those *residual phenomena,* always so pregnant with the germs of knowledge, would, he hoped, at length lead to the discovery of some hitherto unnoticed action, either of some small interplanetary masses of matter such as meteoric matter, or of cometic matter, or of the matter from whence emanates the zodiacal light; or otherwise might disclose the existence of some intra-Mercurial planet, or of some other forces as yet unsuspected in nature. Such was the aim of this eminent astronomer: an aim worthy of the noblest scientific ambition, but one which would demand the aid of the most subtle resources both of observational and of physical astronomy.

The systematic pursuit of this object required many preparatory and most laborious arrangements. Among others it was imperatively necessary to obtain the best available observations of the Sun and the Planets, commencing from a period as remote as possible from the present epoch. For such a purpose the earliest available materials were the observations of Bradley and of his successors at Greenwich; a few others were to be found in the records of Paris and of Königsberg. With regard to the observations made by Bradley more than a century before M. Leverrier commenced his investigations, it was remarked that his instrumental means and his mode of adjusting his instruments, although the best of his day, were not comparable to those put into modern requisition. The aperture of his transit was exceedingly small, the object-glass was not achromatic, the eye-piece admitted of no sliding arrangement, and the records of the state of the adjustment of the instrument are frequently perplexing and obscure. The object which M. Leverrier had in view was to ascertain the true right ascension and the true time of transit of the Sun and the Planets across the meridian at Greenwich during the century which ended on the 1st of January, 1850. Bessel had already done much towards the reduction of Bradley's observations of 36 'Fundamental Stars,' but M. Leverrier did not consider the results as altogether possessing the rigorous precision required for his present purpose, and he accordingly set himself manfully to the task of completing the reduction of the Right Ascensions of these same 36 Fundamental Stars which had been diligently observed

during the entire century. The completion of such a work, under the direction of a single person, *on a single plan*, and conducted with so much intelligence and care, has conferred a great boon upon astronomers, and forms one of the reasons for which we are this day anxious to express our gratitude.

Again, for the effectual prosecution of M. Leverrier's great design, it was necessary to complete and extend, to a far closer amount of approximation, those formulæ for the Planetary Theory which had been invented or perfected by Laplace. That great geometer, in his immortal work the *Mécanique Céleste*, had indicated those terms only in the expressions for the co-ordinates of a planet which he considered would rise to a sensible amount in a numerical computation. It was on this basis that Carlini calculated his Solar Tables, and that Lindenau executed his for *Mercury*, *Venus*, and *Mars*. These tables of Carlini and Lindenau were long used for the computation of the Solar and Planetary co-ordinates in the *Nautical Almanac* with fairly satisfactory results; but for M. Leverrier's purpose of obtaining the small outstanding residuary differences between observations and the best results of the present theory, they were not deemed sufficiently exact.

For the purposes of improving these Solar and Planetary Tables, M. Leverrier, in the year after his appointment to the Directorship of the Paris Observatory, published in the first volume of the *Annales de l'Observatoire Impériale*, a complete reinvestigation of the whole theory of planetary motion on the basis of the method pursued by Laplace. In particular he expanded the *disturbing function* to a greater extent than it had ever been completely expanded before, leaving it with its numerical coefficients computed to the seventh order of small quantities. Thus one most important result of M. Leverrier's labours consists in this, that he has left the general theory in such a state of advanced development, that its practical application henceforth to the case of any particular planet has become greatly simplified and attended with far less labour than had been the case hitherto.

These laborious preliminary calculations having been thus disposed of, and, what is still better, having been published for the advantage of future astronomers, our distinguished Medallist then proceeded to apply them to the construction of Tables for the positions of the Sun, *Mercury*, *Venus*, and *Mars*, carrying the approximations to a greater degree of minuteness than had ever been effected before. These Tables, as we have already stated, have with excellent results superseded those heretofore in use for the computation of the *Nautical Almanac*.

The question will have occurred to those who have listened to the details of the present address — and I greatly wish that it had been possible to present them to you in a more interesting and agreeable form—the question, I say, naturally arises, What is the degree of accordance between the observed places of the Sun and the Planets, and those which have been thus calculated with all this extraordinary care?

In reply to this question I have been favoured by the Astronomer Royal with the following extracts from observations made and recorded at Greenwich. It is necessary to understand that, in order to eliminate mere accidental errors of observation, it is usual to group together several observations extending over intervals of time during which the error of the Tables may be supposed to change sensibly by quantities depending on the first power of the time.

It is to such mean errors of groups that the following numbers refer:—

Solar Tables.

Mean errors in longitude.

From Carlini	1861,	+ 2″·36
	1862,	+ 2·67
	1863,	+ 2·98
From Leverrier	1864,	+ 0·01
	1865,	+ 0·29
	1866,	− 0·18

The greatest discordances between "monthly mean errors in longitude," were

From Carlini	1861,	1″·97
	1862,	2·67
	1863,	5·21
From Leverrier	1864,	1·73
	1865,	1·88
	1866,	1·69

The improvement here is marked, but Carlini's Tables represented the observations well, and the discordances 1″·73, 1″·88, 1″·69, are larger than could be wished. It is possible, however, that these discordances may not be principally sole errors of theory, but errors introduced into the arbitrary constants from small systematic errors in observation.

The following are the greatest discordances of the mean errors in geocentric longitude for *Mercury*, *Venus*, and *Mars*:—

Mercury.

From Lindenau	1861	9″·79
	1862	10·20
	1863	17·94
From Leverrier	1864	5·29
	1865	3·30
	1866	2·04

Venus.

From Lindenau	1862	15″·97
	1863	34·67
	1864	19·05
From Leverrier	1865	5·44
	1866	6·44

Mars.

From Lindenau	1862	8″·81
	1864	13·98
From Leverrier	1866	0·31

The observations in 1866 are, however, very few.

From the above comparisons, it appears that M. Leverrier has made a notable and important advance in the accuracy of his Tables beyond those of his predecessors. We may, perhaps, form a general notion of the amount of accuracy obtained by observing that the average of the discordances between the observed and calculated places of these three planets during any month, rarely or never exceeds a small fraction of the apparent diameter of the disk of the planet itself. Whether these minute discordances, trifling as they are, indicate some slight imperfection in the mode of observing, whether they result from some deficiency in the application of the ordinary theory, or whether they arise from the existence of some exceedingly small masses of matter not taken into the account of the various attractions, it seems as yet impossible to decide. Happily something yet remains to test the efforts and exercise the sagacity of future astronomers.

At the commencement of this Address, I observed that, notwithstanding the forbidding aspect of the long array of figures in the Planetary Tables, to the initiated they contain a history, and are fraught with the memories of life: they are, in fact, the embodiment of some of the most remarkable and most difficult achievements of the human intellect. In order to illustrate what I mean, I shall first of all select one or two of those terms from the series representing the longitude of a Planet, and which arise from the discoveries of the eighteenth century; and then conclude the illustration before us with two other terms intimately associated with the labours of the eminent man whose services to Astronomical Science we hope to recognise to-day.

It follows from comparatively simple dynamical considerations—we say comparatively, because in reality the very simplest processes of Physical Astronomy require a considerable mental effort to be thoroughly grasped—it follows, we say, from the theory of gravitation, that the Moon's disturbing force on the Earth is such as to cause, not the Earth itself, but rather the centre of gravity of the Earth and Moon, to describe an ellipse round the

Sun. This disturbing action can be shown, again happily from considerations of less than usual complexity, to cause a displacement of the Sun in longitude, oscillating backwards and forwards along the ecliptic, and going through all its phases, in the course of a month. From the principles of gravitation alone, this displacement, when at its greatest, can be expressed in terms of the ratio of the masses of the Earth and Moon, and the ratio of the distances of the Earth from the Sun and from the Moon. Now means exist for obtaining the ratio of these masses, as well as the distance of the Earth from the Moon. This greatest displacement, therefore, of the Sun in the ecliptic, arising from the disturbing action of the Moon, can thus, from theory, be virtually expressed in terms of the distance of the Earth from the Sun. But M. Leverrier, by a very careful discussion of the Greenwich Observations, obtained the amount of this displacement of the Sun in longitude, to an unusual degree of accuracy, and he showed it to amount to six seconds and a half in space. By equating, therefore, the *theoretical* value of this *Lunar Equation*, as it is called, thus expressed in terms of the Sun's parallax, with the $6''\cdot5$ obtained from *observation*, the Sun's parallax itself was obtained by M. Leverrier, probably to a greater degree of accuracy than it had ever been obtained before. The result was to increase the solar parallax from the received value of $8''\cdot5776$ to $8''\cdot95$, or what amounts to the same thing, the distance of the Earth from the Sun was thus reduced from about 95 millions to about 91 millions of miles.

It is not pretended that there was anything essentially new in this application of the theoretical value of the *Lunar Equation* in the Solar Tables, to the determination of the Sun's parallax; M. Leverrier's merit therein consists mainly in his able and accurate discussion of the Greenwich Observations of the Sun. By a curious coincidence, about the same time that M. Leverrier proposed this important correction of one of the prime elements in the Solar System, M. Foucault, whose lamented decease we are now deploring, obtained a similar result from careful experiments on the velocity of light; and still further confirmation of the accuracy of the whole investigation has accrued, from a careful discussion of recent observations on *Mars* at his opposition. We shall, perhaps, have completed the history of the case if we incidentally mention that the necessity of greatly increasing the value of the solar parallax had already been indicated by Hansen's accurate determination of that term in the Lunar Theory which expresses the *reaction* on the Moon herself, of that same force which we have seen disturbs the longitude of the Earth. We here refer to these things, not on account of any particular novelty in the processes themselves, but rather as an illustration of the historical circumstances, or it may be even the cosmical relations, which are sometimes wrapped up in the apparently uninteresting coefficients of detached terms in the Planetary Tables. Even in their intellectual aspect alone, such considerations are invaluable.

With reference to those terms in the Planetary Tables, which, as I said at the commencement of this Address, recall to us the grand memories of the Astronomers of the eighteenth century, our comments must necessarily be very brief. Herein I can do little more than hint at those analytical expressions which remind us of that acute sagacity, and that unwearied patience which is born from conviction, whereby Bradley disentangled the combined action of the motions of the Earth and of Light, from a labyrinth of discordances in his observations of the stars. And then other terms closely follow, completing the story of Bradley's fame. Those mysterious symbols indicate to the instructed mind how, in the small residual discordances which still remained, the great English Astronomer detected the action of the Sun and the Moon, displacing hither and thither the axis of the Earth's diurnal rotation, after a complicated but intelligible law.

There is also another term at the commencement of the series for the calculation of the longitude of the Earth, which is intimately associated with the records of the genius of the greatest of the French Astronomers. It is a term relating to the varying eccentricity of the terrestrial orbit. Laplace referred it to the action of the planets on the motion of the Earth round the Sun. He showed how, by slow degrees, and within certain definite limits, these celestial masses must cause an alternate approach or recess of the Earth towards or from the Sun. With a sagacity, perhaps, never surpassed in the history of science, Laplace showed how this alteration in the eccentricity of the terrestrial orbit, must be accompanied by a corresponding small alteration in the average length of *a month*. And here, again, the small but *definite* amount of this alteration in the length of the month, in the hands of this great philosopher, was made subservient to the demonstration of the constancy of the length of the terrestrial *day* within the limits of historical time. All this curious history is, in reality, wrapped up in one little symbol in the series which represents the motions of a planet. But there is something more curious still behind. In process of time our own Adams detected an error both in the physical considerations, and in the analysis, of Laplace. The great French astronomer had, in fact, miscalculated the alteration of the average length of the month in the course of centuries; and then by a curious interaction it followed next that the length of the day itself must have been slowly decreasing, at all events since the date of very certain remote eclipses of the Sun. This scientific romance was completed by the recent demonstration by Delaunay, that the rotation of the Earth is truly retarded to a trifling but definite extent by the friction of the tides. When the history of this recent Episode in Astronomy comes to be fully written, it will probably be acknowledged as one of the most remarkable and instructive narratives in the annals of science.*

* See Addendum to this Address.

There is no part of M. Leverrier's investigation of the Solar Tables in which he has displayed greater acumen and completeness than in his discussion of the secular effects of planetary interactions on the eccentricities of their several orbits. This is a branch of Physical Astronomy peculiarly intricate and laborious, and much interest attaches to it, because, independently of its historical relations already explained, it is here especially that Lagrange, in his magnificient handling of the analysis, unconsciously fell back upon the equivalent of that self-same mode of representing planetary motions by cycle on epicycle, and orb rolling on orb, which was so ingeniously adopted by the ancient astronomers.

But it is not merely on account of the interest thus attaching to this portion of Astronomy, in a geometrical or historical point of view, that I select it now for the consideration of our Society, but much more because the investigation has been supposed by some eminent philosophers to be fraught with information relative to the physical condition of our globe in ages long anterior to historic date.

It has latterly been one of the most pleasing tasks of those who have had the responsible honour of occupying this chair, to expatiate on the unexpected closeness of the connection recently discovered between great cosmical phenomena and ordinary terrestrial physics. This wonderful continuity of plan has been exhibited, we know, in the physical constitution of the Sun and of the Stars, and in the identity of the orbits of revolution of meteoric and cometic matter; and here again, in this perhaps the most intricate of planetary interactions, we stumble, as it were, upon an unexpected relation between the forces of the far distant celestial masses, and one of the most remarkable of geological phenomena: a relation, moreover, which possibly affords us some clue to the distance of that ancient epoch when our globe first became fitted for the abode of animated existence.

We have seen that the eccentricity of the approximate ellipse described by the Earth round the Sun is in a state of extremely slow but constant flux. This effect is brought about not by any alternations in the configurations of the planets, but by a corresponding flux and reflux in the *forms and positions of the orbits* themselves, even *Neptune* contributing a share which is within the limits of calculation. At the present time the Earth is about three millions of miles nearer to the Sun in our northerly winter that in our summer; our coldest month is about 60° Fh. colder than our hottest, and our winter lasts for about eight days longer than our summer. M. Leverrier has calculated* that 200,000 years ago, the Earth approached the Sun by upwards of ten millions of miles nearer in winter than in summer; the winters were then nearly a month longer than the summers, and in the latitude of London there was a difference of about 112° Fh. between the hottest and the coldest periods of the

* *Annales de l'Observatoire*, vol. ii. addition iii. page [29].

year. Eight hundred and fifty thousand years ago these differences, both of distances and of temperatures, were still further exaggerated.

The question then arises, Was any one of these great alterations of terrestrial temperature the cause, or among the concurrent causes, producing that *Glacial period* which has left behind it so many unmistakable and interesting phenomena? This question, surrounded by many complications, arising chiefly from possible alterations in the levels and configurations of terrestrial continents, especially in the neighbourhood of the North Pole, has been discussed with great moderation and in a truly philosophical spirit by Sir Charles Lyell, in the recent edition of his *Principles of Geology*.* The entire argument, as set forth by this eminent geologist, is well worth consultation; I shall here merely state that, upon the whole, Sir Charles Lyell considers there arises a probability that the great Glacial Period began to set in nearly *a million* of years ago. The argument, however, proceeds a step further in advance; for, inasmuch as naturalists have observed that "ninety-five in a hundred of the shells of the Glacial Epoch were specifically identical with those now inhabiting the northern hemisphere, we may consider a million of years to represent the twentieth part of a complete revolution in species." Arguing in this way, the conclusion at last is drawn that, speaking after the roughest of approximations, "*two hundred and forty millions of years may be the entire series of years which has elapsed since the beginning of the Cambrian period.*"

It is but right to remark that, notwithstanding the cautious and philosophical tenor of the reasoning employed, the approximation is admitted to be rough in the extreme; the marvel is that, by the force of the genius so bounteously given to man, he should be enabled to penetrate, or hope to penetrate, into depths of such mysterious profundity. It will be gratifying to the Astronomical Society to learn that our Secretary Mr. Stone† was the first person to extend the calculation of M. Leverrier's formulæ to the remote periods in question. Subsequently, Mr. Croll carried the computations even to a greater extent.

Such, then, are some of the historical circumstances and the physical consequences associated with that apparently forbidding and interminable array of figures‡ and symbols which M. Leverrier has arranged with such indomitable patience and consummate skill, for the computations of the eccentricities of the planetary orbits at periods whose remoteness exceeds the limits of our conceptions.

There may be, and probably there are, some minds to whom these investigations convey an ill-defined but painful sense that man is overstepping his proper place in nature, when he attempts

* Edition *Ten*, vol. i. page 293.

† *Phil. Magazine*, June 1865.

‡ As a matter of curiosity, or for the convenience of such of the Society as may not have easy access to the *Annales de l'Observatoire*, I insert M. Leverrier's

to peer into such extreme remoteness of the past or the future. Assuredly it is not very uncommon to hear similar speculations associated with a rebuke on the score of the *pride of intellect*, which they are presumed to imply. In reference to such apprehensions, it may be sufficient to remark that we know not as yet, and we never can know except by making the trial, what may be the extent of the intellectual powers with which it has pleased the Sovereign Father of all to endow His children.* Assuredly man is bound, in all gratitude and loyalty to the Giver, to exercise to the utmost all the precious gifts which are entrusted to his care. It is a high quality, moreover, of these gifts, that they grow brighter by the using. As to pride of intellect, the gifted men who have been permitted to disclose to their fellow-creatures such onward stretching and magnificent views of the works of the Creator, know too well,—I had almost said, know too sadly, how vast is the labour, how perfect is the patience, and how limited is the power, with which such accessions to their knowledge are acquired; and Pride is not ordinarily the offspring of Labour and Patience and conscious Limitation of Ability.

Such, then, is a brief account of some of the labours of M. Leverrier during the twenty-one years which have elapsed since, in association with our own countryman, in the happiest and most memorable of the discoveries of modern times, he gave to the

formulæ for computing the eccentricity of the terrestrial orbit, as influenced by the disturbances of all the planets excepting *Neptune*.

Eccentricity of the Earth's orbit (t) years after Jan. 1, 1850 $= \sqrt{h^2 + l^2}$

where

$$h = 0''\cdot000526 \sin(g\,t + b) + 0''\cdot016611 \sin(g_1 t + b_1) + 0''\cdot002366 \sin(g_2 t + b_2)$$
$$+ 0''\cdot010622 \sin(g_3 t + b_3) - 0''\cdot018925 \sin(g_4 t + b_4)$$
$$+ 0''\cdot011782 \sin(g_5 t + b_5) - 0''\cdot016913 \sin(g_6 t + b_6)$$

and

$l = 0''\cdot000526 \cos(g\,t + b)$ + the terms above, substituting *cosine* everywhere in the place of *sine*.

$$\begin{array}{lll} g = 2''\cdot25842 & g_1 = 3''\cdot71364 & g_4 = 7''\cdot5747 \\ b = 126^\circ\cdot43'\ 15'' & g_2 = 22\cdot4273 & g_5 = 17\cdot1527 \\ & g_3 = 5\cdot2989 & g_6 = 17\cdot8633 \end{array}$$

$$\begin{array}{ll} b_1 = 27^\circ\ 21'\ 26'' & b_4 = 35^\circ\ 38'\ 43'' \\ b_2 = 126\ 44\ \ 4 & b_5 = -\ 25\ 11\ 33 \\ b_3 = 85\ 47\ 45 & b_6 = -\ 45\ 28\ 59 \end{array}$$

It may be worth observing (to the uninitiated) that each of the seven sines or cosines refers to the interaction of the seven bodies in the solar system: the action of *Neptune* is omitted. See *Annales de l'Observatoire*, vol. ii. p. 170.

* I trust I may be here permitted, without infringing the laws of good taste, to state that I have endeavoured to discuss this and kindred questions, in the Hulsean Lectures recently delivered before the University of Cambridge, and previously in two sermons preached before the British Association in 1866 and 1867. These are now published by Deightons, Bell and Co.

world ample proof of the rare genius with which he has been endowed. These successful labours,—and they necessarily form but a small part of the occupations of his busy life,—are, I am sure, more than sufficient to secure your cordial and unanimous ratification of the act of your Council, whereby they desire to testify to M. Leverrier their deep appreciation of the important services which he has rendered to Astronomical Science.

Admiral Manners,—In the name of the Royal Astronomical Society, I beg you to convey this Medal to M. Leverrier, the eminent Director of the Imperial Observatory of France.

We hope that the sight of it from time to time may properly serve to remind him, how intelligent fellow-labourers in another country appreciate the great work which he has already done in the service of the most sublime of the sciences; we trust also that it may assure him of the sympathy which we feel in the important and difficult investigations in which he is engaged.

Let the cheerfulness and the pride with which we make the award, afford to M. Leverrier an additional ground for the conviction, that we Englishmen entertain a profound respect for the great Philosophers of France.

And now, Gentlemen, my agreeable work in the service of our noble Society has, by inexorable law, at length, and to my regret, come to its close. In this chair I have passed, assuredly, many of the most memorable, and not a few among the most pleasant hours of my life. Owing to your habitual kindness and forbearance, I am sure that other Presidents must have felt, on an occasion like the present, just as I feel.

One chief element in the gratification which I thus venture to express has arisen from the continued and increasing prosperity of the Society itself.

During the eight years of my close and official relations to the Astronomical Society, whether as one of your Secretaries or as your President, I have enjoyed the pleasure of seeing the numbers who attend your evening meetings more than doubled; the Society itself has increased by nearly a hundred members, and its funded property has been augmented by more than two thousand pounds. Such has been the necessary consequence of consistent perseverance in a plan originally well devised; happily such is the natural fruit of a Society dwelling together in unity. Accept my hearty thanks, and, by the continued maintenance of good fellowship in its highest sense, realize my prayer, *Esto perpetua.*

ADDENDUM.

On revising the paragraphs in page 118 relative to the action of the tides in retarding the diurnal rotation of the Earth, I am reminded, both by the Astronomer Royal and by Mr. Stone, that a somewhat modified and more guarded statement is required by the facts of the case.

Soon after M. Delaunay published his investigation of the effects of tidal friction on the length of the day,* Mr. Airy entered upon an examination of the question, and at first came to a conclusion *not* confirmatory of M. Delaunay's result:† on subsequently pushing the approximation a step further, in an Addendum to the same communication in the *Monthly Notices*, the Astronomer Royal says: "I have at length discovered two terms which appear to exercise a real effect on the rotation of the Earth;" and then this important and most interesting memoir concludes as follows: "I am very happy to give my entire assent to the general views of M. Delaunay on the existence of one real cause for the retardation of the Earth's rotation."

Since the publication of these Memoirs by M. Delaunay and Mr. Airy, the whole question has been discussed under a variety of points of view, and various objections have been made to the results supposed to be deduced from the mathematical expressions.

Mr. Stone, for instance, from the very first, declined to accept without reserve, the conclusions deduced by M. Delaunay, mainly on the ground that the hypothesis on which the investigation is founded, presumes that the Moon's action is on a *solid* instead of a *fluid* spheroidal shell surrounding and moving round the Earth.‡

Mr. Airy also observes that his own investigation applies to the motion of water in an *uninterrupted* canal surrounding the Earth, and that the obstacle of a continent, such as that of America, might very seriously modify the final result.

It is, however, due to M. Delaunay to state that he saw himself the extreme difficulty, if not the impossibility, of arriving at any precise quantitative result by means of mathematical calculation alone; he says:§ "The exact calculation of the retardation due to the combined action of the Moon and Sun, would require a knowledge of all the circumstances of the tides *as well along the shores as in mid-ocean*. Such a direct calculation is impossible; the actual retardation can only be found indirectly by means of the lunar acceleration, as determined by observation;

* *Comptes Rendus*, Dec. 1865, and *Monthly Notices*, Jan. 1866.
† *Monthly Notices*, April, 1866, p. 227.
‡ Ib. Jan. 1866. § Ib. Jan. 1866, p. 89.

and this gives a new interest to the comparisons of the lunar tables with the ancient eclipses, in the view of thereby arriving at the true value of the lunar acceleration."

At present, then, the case stands thus,—the Lunar Tables, if calculated on the principles of gravitation alone, as expounded by Messrs. Adams and Delaunay, and as confirmed by other mathematicians, will not exactly represent the Moon's true place at intervals separated by 2000 years, provided the length of the day is assumed to be uniform and unaltered during the whole of the intervening period. There are grounds, however, for at least suspecting that, owing to the effects of tidal action, the diurnal rotation is, and has been, in a state of extremely minute retardation, but the mathematical difficulties of the case, owing greatly to the interposition of terrestrial continents, are so great that no definite quantitative results have hitherto been attainable. The solution of the difficulty is one of those questions which are reserved for the Astronomy of the future.

The Meeting then proceeded to the election of the Officers and Council for the ensuing year, when the following Fellows were elected:—

President:

Admiral R. H. Manners.

Vice-Presidents:

J. C. Adams, M.A. F.R.S., Lowndean Professor of Astronomy, Cambridge.
G. B. Airy, M.A. F.R.S., Astronomer Royal.
A. Cayley, M.A. F.R.S., Sadlerian Professor of Geometry, Cambridge.
Rev. Charles Pritchard, M.A. F.R.S.

Treasurer:

Samuel Charles Whitbread, Esq., F.R.S.

Secretaries:

William Huggins, Esq. F.R.S.
Edward J. Stone, Esq. M.A.

Foreign Secretary:

Lieut.-Col. Alexander Strange, F.R.S.

Council:

Rev. Professor Challis, M.A. F.R.S.
Rev. W. R. Dawes, F.R S.
Warren De La Rue, Esq. F.R.S.
Edwin Dunkin, Esq.
George Knott, Esq.
William Lassell, Esq. F.R.S.
J. Norman Lockyer, Esq.
Rev. Robert Main, M.A. F.R.S., Radcliffe Observer.
Captain William Noble.
Richard A. Proctor, Esq. B.A.
William Simms, Esq.
Isaac Todhunter, Esq. M.A. F.R.S.

The Lunar Crater Linné.

Captain Noble remarks, in regard to the Editor's note, p. 49, that, while Mr. Huggins' sketch shows a minute black crater surrounded by an ill-defined nebulous mass, his own exhibits a relatively shallow crater casting a perceptible shadow from the W. and S.W. wall, but without exhibiting any trace whatever of the smaller one.

Resolution of Council.

At the Council held Saturday, February 8, it was resolved that a paper cannot in general be read at an Evening Meeting unless the same shall have been deposited at the Society's rooms by noon of the day of Meeting.

For Sale.

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MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

Vol. XXVIII. *March* 13, 1868. No. 5.

Admiral Manners, President, in the Chair.

The Rev. Joseph Spear, Chaplain, Bengal Establishment, Meerut,

was balloted for and duly elected a Fellow of the Society.

On the Comets 1857, *III. and V., and* 1867, *III.* By M. Hoek, Director of the Observatory of Utrecht. (Translation.)

In an addition to my Memoirs on Cometary Systems, see *Monthly Notices*, vol. xxvi. page 204, I have indicated the point of the sphere

IV. $\lambda = 75^{\circ}\cdot5 \quad \beta = -51^{\circ}\cdot7$ .. Mean equinox of 1864·0,

as being probably a radiant point of cometary orbits.

I have therefore regarded as a remarkable circumstance, giving much interest to this point, its small distance from the point

$\lambda = 73^{\circ}\cdot2 \quad \beta = -51^{\circ}\cdot6$ .. Mean equinox of 1864·0,

which was the point of intersection of the orbits obtained for the Comets 1857, III. and V.

I did not hesitate to attribute to these two bodies a common origin, considering the extreme resemblance of all the elements of their orbits, and the short interval between their appearance.

The Comet 1867, III. has just given an unexpected confirmation to this view. The circle which is the intersection of its orbit with the sphere passes through almost the same point of the sky.

The planes of the three orbits intersect therefore in the same line, which is necessarily parallel to the direction of the initial motion of the Comets.

Admitting for the orbits the following elements,

	Comet 1857, III.	1857, V.	1867, III.	
T	1857·54	1857·74	1867·85	
π	157° 52′	139° 54′	112° 58′	Mean equ. of 1864·0.
☊	23 47	15 4	64 42	
i	121 3	123 57	96 14	
q	0·3675	0·5628	0·3333	
Calculator.	Villarceau.	Linsser.	Oppolzer.	

I find for the points of intersection

of the Orbits	1857, III. and 1857, V.	$\lambda = 73° 12'$	$\beta = -51° 36'$
„	1857, III. and 1867, III.	72 32	$-$ 51 19
„	1857, V. and 1867, III.	72 33	$-$ 51 23

of which the first is only half-a-degree distant from the two others.

These three Comets, then, have a common origin.

As to the aphelia they are situated at a considerable distance from the radiant point of the orbits. I find

For the Comet	Aphelion.		Distance of the Aphelion from the Radiant Point.
1857, III.	$\lambda = 51°\cdot8$	$\beta = -38°\cdot0$	20°·0
1857, V.	53·8	$-$ 42·9	15·4
1867, III.	68·5	$-$ 31·5	20·1

but, what is remarkable, all the aphelia are on the same side as regards the radiant point. In following the orbits in the direction of the retrograde motion, we meet the radiant point before we arrive at the aphelia. The last ten years have thus furnished us with two cometary systems, each composed of three members; first, that of the years 1860 and 1863, then that of the years 1857 and 1867.

It appears that it would be to mistake the principles of the theory of probabilities, if we attributed all these coincidences to mere chance.

Since I have been occupied with these researches, the calculations of M. Schiaparelli on the current of meteors coming from the stellar spaces have strongly corroborated my conclusions. This Astronomer has succeeded in showing the intimate con-

nexion which there is between comets and falling stars; an important discovery, and known now to all the world. Naturally it has suggested the idea of seeking, if I could not find, a connexion between cometary systems and falling stars. In a subsequent Memoir I shall occupy myself with the theory which ought to serve as a guide in this investigation.

On the Phenomena which a very extended Swarm of Meteors coming from Space presents after its entry into the Solar System. By M. Hoek, Director of the Observatory of Utrecht. (Translation.)

I propose to examine in this Memoir the phenomena which will be presented by a swarm of corpuscules coming to us from the stellar spaces, and which is sufficiently extended to embrace the whole terrestrial orbit, that is, to give us a continuous rain of meteors during an entire year.

I shall determine the orbit of each molecule, the density of the swarm in the neighbourhood of the terrestrial orbit, the variations in the position of the radiant point, and lastly, the perturbations produced by the attraction of the Earth. But as we are only concerned with a first approximation, I shall admit that these corpuscules do not exercise any mutual influence, and that consequently their initial motions are parallel, and further that the initial velocity common to all the particles is that given by parabolic orbits round the Sun. Lastly, I shall neglect the ellipticity of the orbit of the Earth, and I shall consider this planet as a body composed of homogeneous and concentric spherical layers.

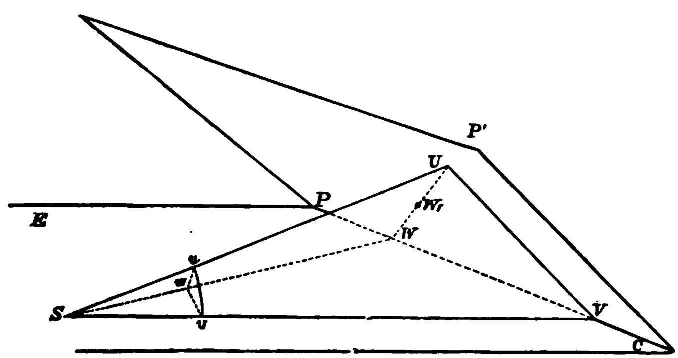


Fig. 1.

§ 1. Let E C (fig. 1) be the plane of the ecliptic, S the Sun, S U a line parallel to the initial motion of the swarm, motion

with which each molecule enters into the sphere of activity of the Sun.

Let us write $SU = A$, and determine the direction of this line by the longitude L and the latitude B of the point U; and, to fix the ideas, let this latitude be taken to be northern.

Let PP' be a plane normal to the line SU, cutting the ecliptic in PC. Lastly, let SUV be a third plane normal to the two others and containing the line SU. We have $USV = B$.

Suppose now that a corpuscule passes through any point whatever W situate in the plane PP' and determined by the co-ordinates $VUW_1 = \zeta$, $UW_1 = s$. The orbit of the meteor round the Sun will be included in the plane USW, the position of which is easily determined. For this purpose let us represent to ourselves about the Sun as centre a sphere radius unity, and we shall have a spherical triangle uvw, the elements of which will be

$$uv = B, \quad uw = n, \quad vw = h, \quad uvw = 90^\circ, \quad vuw = \zeta,$$

whence

$$\left.\begin{aligned} \tan h &= \tan \zeta \sin B, \\ \tan B &= \tan n \cos \zeta, \\ \cos n &= \cos B \cos h, \end{aligned}\right\} \quad (1)$$

or if we prefer to introduce the descending node and the inclination of the orbit, that is to say, if we write $h = ☋ - L$, and the angle $uwv = i$, then

$$\left.\begin{aligned} \tan(☋ - L) &= \tan \zeta \sin B, \\ \tan i &= \frac{\tan B}{\sin(☋ - L)}, \\ \cos i &= \cos B \sin \zeta. \end{aligned}\right\} \quad (2)$$

Secondly, we shall have for the excentricity of the orbit e, for its parameter p, and for the perihelion distance q, the general formulæ

$$\left.\begin{aligned} e^2 - 1 &= \frac{c^2}{\mu^2}\left(V^2 - 2\frac{\mu}{R}\right) = \frac{c^2}{\mu^2}\left[V^2 - 2\frac{\mu}{A}\left(1 + \frac{s^2}{A^2}\right)^{-\frac{1}{2}}\right], \\ p &= q(1+e) = \frac{c^2}{\mu}, \end{aligned}\right\} \quad (3)$$

where we have

V, the initial velocity,

μ, the constant of solar attraction (the k^2 of Gauss),

$\frac{1}{2}c$, the area described by the radius vector in the unity of time ($c = Vs$),

R, the initial distance SW_1, $= \sqrt{A^2 + s^2}$.

Let us now admit that for the corpuscule passing through U, that is, for which $s = 0$, the velocity is that in a parabola, consequently $e = 0$, and the formula (3) will give

$$V^2 = 2\frac{\mu}{A}, \tag{4}$$

In this case all the other corpuscules will describe hyperbolas, but we may say that all these orbits will not sensibly differ from parabolas, so long as we only occupy ourselves with the meteors which meet the orbit of the Earth. In fact, this restriction gives $q \leqq 1$, and since from the formulæ (3) and (4)

$$e - 1 = q\frac{2}{A}\left(\frac{1}{2}\frac{s^2}{A^2} - \frac{3}{8}\frac{s^4}{A^4} + \ldots\right) = \frac{q}{A}\frac{s^2}{A^2}\left(1 - \frac{3}{4}\frac{s^2}{A^2} + \ldots\right), \tag{5}$$

the excess of e above unity is a very small quantity. In order to calculate it, we then have with a close approximation, from (3) and (4),

$$2q = \frac{V^2 s^2}{\mu} = 2\frac{s^2}{A}, \tag{6}$$

which gives for the formula (5)

$$e - 1 = \left(\frac{q}{A}\right)^2\left(1 - \frac{3}{4}\frac{q}{A} + \ldots\right), \tag{7}$$

that is to say, that for $q = 1$, $A = 10000$, the excentricity will not sensibly differ from unity, and consequently q will not sensibly differ from the value given by the formula (6).

Lastly, the angle M between the axis and the asymptote will be very approximately given by the equation,

$$\tan M = \sqrt{e^2 - 1} = \sqrt{2(e-1)} = \frac{q}{A}\sqrt{2}. \tag{8}$$

so that, according to the foregoing suppositions, we shall have $M = 29''$, a quantity which may be neglected.

We shall therefore consider each molecule as describing a parabola the perihelion distance of which is given by the formula (6), and the axis of which coincides with the line S U.

It remains to inquire what is the geometric locus in the plane P P′ of all the points W_1 through which pass the molecules which afterwards meet the terrestrial orbit.

We have for the orbit of each molecule

$$r(1 + \cos v) = 2\frac{s^2}{A}, \tag{9}$$

or introducing the relations $r = 1$, $v = 180^\circ + n$, this becomes

$$1 - \cos n = 1 - \cos h \cos B = 2 \frac{s^2}{A}, \qquad (10)$$

whence from the formulæ (10) and (1)

$$\cos^2 n\,(1 + \tan^2 n) = 1 = \left(2 \frac{s^2}{A} - 1\right)^2 \left(1 + \frac{\tan^2 B}{\cos^2 \zeta}\right), \qquad (11)$$

the equation of the required curve in the polar co-ordinates s and ζ. To obtain it in rectangular co-ordinates, we may write $s^2 = x^2 + y^2$ and $\frac{1}{\cos \zeta} = \frac{s}{x}$, so that the line U V has in fact been chosen for the axis of x. This gives

$$4 x^4 + 4 x^2 y^2 (1 + \sin^2 B) + 4 y^4 \sin^2 B - 4 A x^2 - 4 A y^2 \sin^2 B + A^2 \sin^2 B = 0$$

a curve which is symmetric in regard to each axis.

For $y = 0$ the equation gives

$$x_1 = \pm \sqrt{\frac{1}{2} A (1 + \cos B)}, \quad x_2 = \mp \sqrt{A (1 - \cos B)},$$

where the upper signs belong to the corpuscules which, as they cut the orbit of the Earth, are in their descending node; the lower signs to those which only cut the Earth's orbit after they have gone round the Sun and arrived at the ascending node.

For $x = 0$, the equation giv s $y = \pm \sqrt{\frac{1}{2}} A$,

„ $B = 90^\circ$ „ $x^2 + y^2 = \frac{1}{2} A$,

„ $B = 0$ „ $x^2 = 0$ and $x^2 + y^2 = A$.

that is to say, the line P C, and a circle having its centre on this line. In the latter case $q = 1$, and from the formula (10), $\cos h = -1$, which are co-ordinates of the perihelion common to all the orbits which pass through any point of the circle.

§ 2. What is the density of the swarm at any point of the Earth's orbit, taking for unity the density in the neighbourhood of the plane P P'?

To answer this question let us follow the motions of the eight molecules, the initial positions of which at the same instant were expressed by the co-ordinates,

No. 1.	by	$(s,$	$\zeta,$	$A),$
2.	,,	$(s,$	$\zeta + d\zeta,$	$A),$
3.	,,	$(s + ds,$	$\zeta,$	$A),$
4.	,,	$(s + ds,$	$\zeta + d\zeta,$	$A),$
5.	,,	$(s,$	$\zeta,$	$A + dA),$
6.	,,	$(s,$	$\zeta + d\zeta,$	$A + dA),$
7.	,,	$(s + ds,$	$\zeta,$	$A + dA),$
8.	,,	$(s + ds,$	$\zeta + d\zeta,$	$A + dA).$

Originally they formed a rectangular parallelopiped of the volume $ds \times s\,d\zeta \times dA$. We have to find the volume comprised between the positions when they have arrived near the terrestrial orbit.

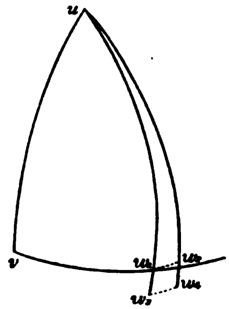


Fig. 2.

Everything being symmetrical about the line S U, it at once appears that Nos. 1 and 2 will arrive at the same instant at the points w_1 and w_2 of the sphere radius unity described about the Sun, and that $u\,w_1 = u\,w_2$ (fig. 2), Nos. 3 and 4 will arrive a little later at w_3 and w_4; Nos. 5 to 8 will follow the others at a distance sensibly constant for all these numbers.

The calculation may be conducted in two manners.

I. We may consider first what happens in the plane $u w_1 w_3$, and multiply by $w_1 w_2$ the area of the parallelogram formed by the Nos. 1, 3, 5, and 7 (fig. 3). At the moment that No. 1 arrives

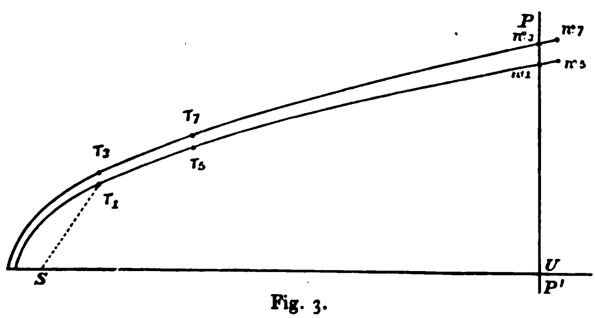


Fig. 3.

at τ_1 at the distance 1 from the Sun, the others will be at τ_3, τ_5 and τ_7.

The primitive velocity being $\sqrt{\frac{2\mu}{A}}$, that at the distance 1 $= \sqrt{2\mu}$, we have

$$dA = \sqrt{\frac{2\mu}{A}}\,dt, \qquad \tau_1\tau_3 = \sqrt{2\mu}\,dt = \sqrt{A}\,dA. \qquad (13)$$

The equation $y^2 = p^2 + 2px$ of the parabola $\tau_1 \tau_5$ for the origin S then gives for the distance of the two neighbouring parabolas measured in a direction parallel to the axis of y,

$$dy = \frac{p+x}{g}\,dp = \frac{r}{y}\,dp,$$

whence writing $r = 1$, $y = \sin n$, for the distance of the two parabolas $\tau_1 \tau_5$ and $\tau_3 \tau_7$, we have

$$dy \cos\frac{1}{2}n = \frac{dp}{2\sin\frac{1}{2}n} = \frac{dy}{\sin\frac{1}{2}n} = \frac{2s\,ds}{A\sin\frac{1}{2}n}. \qquad (14)$$

The parallelogram $\tau_1\,\tau_3\,\tau_7\,\tau_5$, has, therefore, a surface

$$\tau_1\,\tau_5 \times dy\cos\frac{1}{2}n = \frac{2s\,ds\,dA}{\sin\frac{1}{2}n\,\sqrt{A}}, \qquad (15)$$

and in a different plane the Nos. 2, 4, 6, 8, will have perfectly similar positions, and will form a parallelogram of the same shape and dimensions.

Finally, in figure 2,

$$w_1 w_2 = w_3 w_4 = \sin n\,d\zeta, \qquad (16)$$

whence the volume comprised between the eight molecules when they arrive at the terrestrial orbit is

$$\frac{4\cos\frac{1}{2}n}{\sqrt{A}}\,ds\,.\,s\,d\zeta\,.\,dA,$$

and the density is thus

$$D = \frac{\sqrt{A}}{4\cos\frac{1}{2}n}. \qquad (17)$$

II. We may diminish the co-ordinate A of Nos. 3 and 4 by a certain quantity so chosen that they arrive at the distance 1 from the Sun simultaneously with Nos. 1 and 2. Doing the same thing for the co-ordinate $A + dA$ of Nos. 7 and 8, the primitive parallelopiped will have changed its form, preserving a constant volume.

In this case Nos. 5 to 8 will be at a distance $1 + dr$ from the Sun at the instant when Nos. 1 to 4 have reached the sphere radius 1. We have, therefore, to multiply the surface $w_1\,w_2\,w_3\,w_4$, by dr.

We have already

$$w_1 w_2 = \sin n \, d\zeta, \qquad (16)$$

and, differentiating the formula (10),

$$w_1 w_3 = dn = \frac{4 s \, ds}{A \sin n}. \qquad (18)$$

It remains to find dr. The general formulæ

$$r^2 dv = \sqrt{p\mu} \, dt,$$

$$r = \frac{p}{1 + e \cos v}, \text{ with its differential } \quad dr = \frac{r^2}{p} e \sin v \, dv,$$

give

$$r\,dr = \sqrt{(e^2 - 1) r^2 + 2pr - p^2} \sqrt{\frac{\mu}{p}} \, dt. \qquad (19)$$

Hence, in our case where $e = 1$, $p = 2q$, we have

$$r\,dr = \sqrt{r - q} \sqrt{2\mu} \, dt.$$

and, considering dt as a constant quantity,

$$r\,dr = \sqrt{\frac{r - q}{R - q}} \, R \, dR, \qquad (20)$$

a formula which for $R = 1$, $R\,dR = A\,dA$, gives

$$dr = \sqrt{\frac{1 - q}{R - q}} \, A \, dA,$$

or with a very close approximation

$$dr = A\,dA \sqrt{\frac{1 - q}{A - \frac{1}{2} q}} = \sqrt{A(1 - q)} \, dA,$$

the volume comprised between the eight molecules becomes therefore

$$w_1 w_2 \times w_1 w_3 \times dr = 4 \sqrt{\frac{1 - q}{A}} \, ds \, . \, s\,d\zeta \, . \, dA,$$

and the required density, as before

$$D = \frac{1}{4} \sqrt{\frac{A}{1 - q}} = \frac{\sqrt{A}}{4 \cos \frac{1}{2} n}.$$

It is to be remarked that D is the real density. The apparent density, or number of meteors which fall during a certain time,

will depend not only on D, but also on their relative velocity in regard to the Earth, and on the perturbations which this planet produces in their movements.

The following table, calculated from the formulæ (1) and (17) for B = 51° 30′ and for successive values of *h*, gives an *aperçu* of the densities of different parts of the same swarm at the moment when they meet the orbit of the Earth. The density is taken to be 1 for A = 10000.

h	*n*	D
°	° ′	° ′
± 0	51 30	27 7
± 15	53 3	27 9
± 30	57 23	28 5
± 45	63 53	29 5
± 60	71 52	30 9
± 75	80 44	32 8
± 90	90 0	35 3
± 105	99 16	38 6
± 120	108 8	42 6
± 135	116 7	47 2
± 150	122 37	52 2
± 175	126 57	56 0
± 180	128 30	57 5

§ 3. What is the radiant point which the swarm will present at any point of the Earth's orbit ?

It appears, in the first place, that at every instant there exist two of these points, one of them for the meteors which are at their descending node, the other for those which, having attained their ascending node, have the same velocity but in a directly contrary direction. The two may be calculated successively.

For this purpose it is to be remembered that every tangent to a parabola divides into two equal parts the angle formed by the radius vector and the diameter produced.

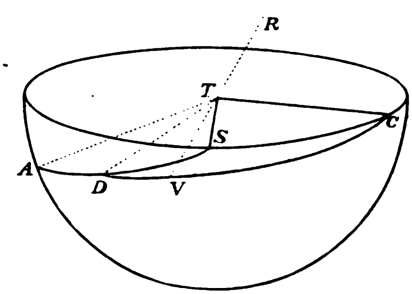


Fig. 4.

Suppose, then, fig. 4, that T is the Earth, occupying the

centre of a sphere whereon A denotes the point opposite to V; that is to say, that T A is taken in space parallel to the line S U. Let S be the Sun, D a point dividing the arc A S into two equal parts; the meteor, as it meets the Earth, will have the direction T D, and, we may add, the velocity $\sqrt{2\mu}$. Hence, taking the arc S C $= 90^\circ$, T C will be the direction of the motion of the Earth taken in the inverse sense. Whence it follows that a parallelogram constructed on the lines T C and T D with the lengths $\sqrt{\mu}$ and $\sqrt{2\mu}$ will give, by its diagonal, the relative motion of the meteors in direction and magnitude. This diagonal, situate in the plane D T C, will cut the sphere somewhere in V. Thus the point V will be opposite to the radiant point R.

For the calculation, we shall unite the points A, D, S, C, and V with the north pole P, and express their position in longitude and polar distance.

Taking l for the longitude of the Earth, seen from the Sun, we shall have

For A	longitude	$180^\circ + L$	Polar Dist.	$= P = 90^\circ + B$
„ S	„	$180 + l$		$= 90^\circ$
„ C	„	$270 + l$		$= 90$
„ D	„	$180 + L + \lambda_1$		$= \pi_1$
„ V	„	$180 + L + \lambda_2$		$= \pi_2$.
„ R	„	$l + \lambda_2$		$= 180 - \pi_2$

we write moreover $DC = H$, $DV = \alpha$, and $AS = n =$ arc uw of figure 1.

In order to facilitate the calculation, let us represent a spherical triangle M N O (fig. 5), divided into two parts by an arc of great circle N P. Let $\Phi + \Psi = N$, $\varphi + \psi = n$, $m = 90^\circ$, we shall have, equating the values of sin O and of cos O derived successively from the triangles N O P and N O M,

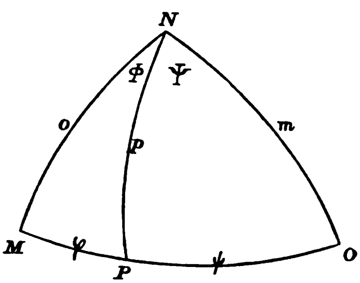


Fig. 5.

$$\sin p = \sin o \frac{\sin \psi}{\sin \Psi} \frac{\sin N}{\sin n}, \quad \cos p = \cos o \frac{\sin \psi}{\sin N}, \quad (22) \text{ and } (23)$$

$$\tan p = \tan o \frac{\sin N}{\sin \Psi}, \qquad (24)$$

$$\sin p \sin \Psi = \sin o \sin \psi \frac{\sin N}{\sin n}, \quad \sin p \cos \Psi = \cos \psi, \qquad (22) \text{ and } (25)$$

$$\tan \Psi = \tan \psi \sin o \frac{\sin N}{\sin n}, \tag{26}$$

$$\cos n = \sin o \cos N. \tag{27}$$

Applying to the triangle A P S the formulæ (22), (24), (26), 27), we have

$$n = n, \phi = \psi = \frac{1}{2} n, o = P, p = \varpi_1, N = l - L, \Psi = l - L - \lambda_1,$$

whence

$$\sin \varpi_1 = \frac{\sin P \sin (l - L)}{2 \cos \frac{1}{2} n \sin (l - L - \lambda_1)}, \quad \tan \varpi_1 = \tan P \frac{\sin (l - L)}{\sin (l - L - \lambda_1)},$$

(28) and (29)

$$\tan (l - L - \lambda_1) = \frac{\sin P \sin (l - L)}{2 \cos^2 \frac{1}{2} n}, \quad \cos n = \sin P \cos (l - L).$$

(30) and (31)

Applying next to the triangle D P C the formulæ (24), (26), and (27), we have

$$n = H, \phi = \alpha, \psi = H - \alpha, o = \varpi_1, p = \varpi_2, N = 90^\circ + l - L - \lambda_1, \Psi = 90^\circ - \lambda_2,$$

whence

$$\tan \varpi_2 = \tan \varpi_1 \frac{\cos (l - L - \lambda_1)}{\cos \lambda_2}, \quad \cot \lambda_2 = \frac{\tan (H - \alpha)}{\sin H} \sin \varpi_1 \cos (l - L - \lambda_1) -$$

(32) and (33)

$$\cos H = - \sin \varpi_1 \sin (l - L - \lambda_1). \tag{34}$$

The formulæ (28), (30), and (33), give

$$\tan \lambda_2 = \frac{\sin H \cot (H - \alpha)}{\cos \frac{1}{2} n}, \tag{35}$$

the formulæ (29), (30), and (32),

$$\tan \varpi_2 = \frac{2 \cos^2 \frac{1}{2} n}{\cos P \cos \lambda_2}, \tag{36}$$

the formulæ (28) and (34),

$$\cos H = -\frac{\sin P \sin (l - L)}{2 \cos \frac{1}{2} n}, \tag{37}$$

and the problem will thus be resolved as soon as we know the value of cot (H — α) To calculate it, we have in a rectilinear triangle, the half of the parallelogram of the motions,

Angles α, $H - \alpha$, and $180° - H$.

Corresponding sides $\sqrt{\mu}$, $\sqrt{2\mu}$, and $\sqrt{(3 + 2\sqrt{2} \cos H) \mu}$,

whence

$$\frac{\sin^2 H}{\sin^2 (H - \alpha)} = \frac{3 + 2\sqrt{2} \cos H}{2}, \quad \cos^2 (H - \alpha) = \frac{(1 + \sqrt{2} \cos H)^2}{3 + 2\sqrt{2} \cos H},$$

$$\sin H \cot (H - \alpha) = \frac{1 + \sqrt{2} \cos H}{\sqrt{2}} = \cos 45° + \cos H. \tag{38}$$

To resume, the system of formulæ necessary for the calculation is

$$\left.\begin{array}{l}
\cos n = \sin P \cos (l - L), \\
2 \cos \frac{1}{2} n \cos H = -\sin P \sin (l - L), \\
\tan \lambda_2 = \dfrac{\cos 45° + \cos H}{\cos \frac{1}{2} n}, \quad \tan \pi_2 = \dfrac{2 \cos^2 \frac{1}{2} n}{\cos P \cos \lambda_2}, \\
\text{longitude of R} = l + \lambda_2, \\
\text{N. latitude of R} = \pi_2 - 90°,
\end{array}\right\} \tag{39}$$

In the second place, we have to occupy ourselves with the second radiant point belonging to the meteors which are at the

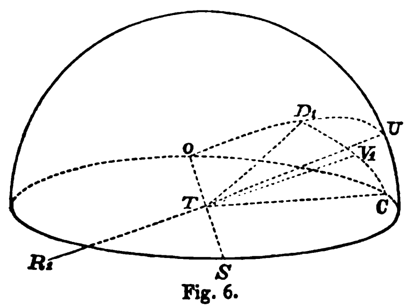


Fig. 6.

ascending node. In this case, taking (fig. 6) U for the point

opposite to A, and O for that opposite to S, let D_1 be the point situate at the middle of the arc UO, and V_1 the point marked on the sphere by the diagonal of the parallelogram constructed on the lines TD_1 and TC. We have for

for U,	longitude	$= L$	polar distance	$= 180° - P$
„ O	„	$= l$	„ „	90
„ C	„	$= l - 90°$	„ „	90
„ D_1	„	$= L + \lambda_1$	„ „	ϖ_1
„ V_1	„	$= l - \lambda_2$	„ „	ϖ_2
„ R_1	„	$= 180° + l - \lambda_2$	„ „	$180 - \varpi_2$

and then

$$D_1C = H, \quad D_1V_1 = a, \quad OU = n,$$

and the repetition of the calculation gives

$$\left.\begin{aligned}
\cos n &= \sin P \cos (l - L),\\
2\cos\frac{1}{2}\cos H &= \sin P \sin (l - L),\\
\tan \lambda_2 &= \frac{\cos 45° + \cos H}{\cos \frac{1}{2} n}, \quad \tan \varpi_2 = -\frac{2\cos^2 \frac{1}{2} n}{\cos P \cos \lambda_2},\\
\text{Longitude of } R_1 &= 180° + l - \lambda_2,\\
\text{N. latitude of } R_1 &= \varpi_2 - 90°.
\end{aligned}\right\} \quad (40)$$

Hence, introducing the longitude of the Sun $= \odot$, the latitude of the point $U = B_1$, that of the point $R = \beta_2$, and uniting the formulæ for the two cases, we have

$$\left.\begin{aligned}
\cos n &= -\cos B \cos (\odot - L),\\
\cos H &= \frac{\cos B \sin (\odot - L)}{2\cos \frac{1}{2} n},\\
\tan \lambda_2 &= \frac{\cos 45° \pm \cos H}{\cos \frac{1}{2} n}, \quad \tan \beta_2 = \pm \frac{\sin B \cos \lambda_2}{2\cos^2 \frac{1}{2} n},\\
\text{Long. of } R &= 180° + \odot + \lambda_2 = \odot - \lambda_2,\\
\text{N. lat. of } R &= \beta_2,
\end{aligned}\right\} \quad (41)$$

where the upper signs belong to the meteors at the descending node, the lower ones to those at the ascending node.

The knowledge of the relative motion is a great step in advance towards finding the apparent density of the rain of meteors.

This will be proportional to

$$D\sqrt{(3+2\sqrt{2}\cos H)\mu} = \frac{\sqrt{A\mu}}{4\cos\frac{1}{2}n}\sqrt{3 \pm \frac{1.4\cos\beta\sin(\odot - L)}{\cos\frac{1}{2}n}} \quad (42)$$

on the supposition that the attraction of the Earth has no influence on the motion of the corpuscules. But this action being sometimes very sensible, it follows that the formula (42) gives only a first approximation to the apparent density.

The following table, calculated from the formula (41), where U is taken to be the radiant point of the Comets of 1857 and 1867, will show how considerable are the annual variations of the radiant points. With $L = 72° 45'$, $B = -51° 30'$, I find

				The Point R.		The Point R_1.	
Date.	$\odot$	n.	H.	Long.	Lat.	Long.	Lat.
	° ′	° ′	° ′	° ′	° ′	° ′	° ′
Dec. 4	252 45	51 30	90 0	110 53	−20 46	214 37	+20 46
Jan. 3	282 45	57 23	100 13	133 53	−23 32	237 31	+19 42
Feb. 2	312 45	71 52	109 26	157 33	−28 26	260 40	+20 8
Mar. 3	342 45	90 0	116 7	183 26	−36 13	284 24	+22 1
Apr. 2	12 45	108 8	117 20	215 39	−46 19	309 27	+27 3
May 3	42 45	122 37	108 55	261 20	−53 0	337 43	+35 36
June 3	72 45	128 30	90 0	311 11	−47 21	14 19	+47 21
July 4	102 45	122 37	71 5	347 47	−35 36	64 10	+53 0
Aug. 5	132 45	108 8	62 40	16 3	−27 3	109 51	+46 19
Sept. 4	162 45	90 0	63 53	41 6	−22 19	142 4	+36 13
Oct. 5	192 45	71 52	70 34	64 50	−20 8	168 57	+28 26
Nov. 4	222 45	57 23	79 47	87 59	−19 42	191 37	+23 32

§ 4. In the last place, we proceed to calculate the influence of the attraction of the Earth on the density of the rain of meteors, and on the position of the radiant point.

The relative velocity $\sqrt{(3+2\sqrt{2}\cos H)\mu}$ has a minimum for $H = 180°$, and the value is then $= 0{\cdot}414\sqrt{\mu}$. With this minimum velocity the meteors will describe hyperbolic orbits round the centre of the Earth. In fact, admitting for a moment that one day before their fall they have not yet undergone any attraction from the Earth, they will then be at a distance $= 0{\cdot}414\sqrt{\mu}$ unities, and we shall have $V^2 > \frac{2g}{r}$, that is, in numbers

$$(0{\cdot}414)^2\mu > \frac{2\mu}{319455} \times \frac{1}{0{\cdot}414\sqrt{\mu}} \quad \text{or} \quad (0{\cdot}414)^2 > 0{\cdot}00879.$$

This inequality would be still greater if we had introduced the attraction of the Earth during the preceding days, and the hyperbolic character of the orbit would have become still more marked. Having then established it for the smallest angular velocity, we have in fact established it for all the meteors which the Earth meets during its annual revolution.

We may therefore resume the reasonings of §§ 1 and 2. Only we must in figure 1 replace the point S by the Earth, the point U by the radiant point R_1, the parabolic orbit of each molecule by a hyperbolic orbit. We may take for the plane PP′ a plane normal to the asymptotes (parallel to each other) of all the hyperbolas. Lastly, we have to consider the relative velocity V as belonging to an infinite distance, which gives for the dimensions of the orbits

$$\left.\begin{array}{l} p = q\,(e+1) = a\,(e^2-1) = \dfrac{V^2 s^2}{g},\quad e^2 = 1+\dfrac{V^4 s^2}{g^2}, \\ a = \dfrac{g}{V^2},\quad \tan M = \dfrac{V^2 s}{g} = \dfrac{s}{a},\quad \cos M = \dfrac{1}{e},\ \sin M = \dfrac{s}{ae}, \end{array}\right\} \quad (43)$$

where p, q, e, s, and M signify, as in §§ 1 and 2, a is the semi-axis major, and g the constant of terrestrial attraction.

The total deviation undergone, in consequence of this attraction, by a meteor which passes near the Earth will thus be $180° - 2\,M = 2\,\delta$, so that we shall have

$$\tan\delta = \cot M = \frac{g}{V^2 s}, \quad (44)$$

where δ will be larger as s is smaller.

What is then the value of δ for a meteor which grazes the surface of the Earth?

The formulæ (43) give

$$e+1 = \frac{V^2 s^2}{g\,q},\quad e-1 = \frac{V^2}{g}\,q,\quad 2 = \frac{V^2}{g}\left(\frac{s^2}{q} - q\right), \quad (45)$$

and for $q = 1$,

$$s^2 = 1 + 2\,\frac{g}{V^2},\quad \tan\delta = \frac{g}{V^2}\left(1 + 2\,\frac{g}{V^2}\right)^{-\frac{1}{2}}. \quad (46)$$

In the numerical calculations to be based upon these formulæ, it would be necessary to pay attention to reduce g and V to the new unity which has just been introduced. In fact, instead of the radius of the terrestrial orbit, we have taken as unity of distance the radius of the Earth; we must therefore, if π be the parallax of the Sun, write

$$g = \frac{\mu}{319455}\,(\cot\pi)^3,\quad V^2 = (3 + 2\,\sqrt{2}\cos H)\,\mu\cot^2\pi,$$

or, for $\pi = 8''\cdot916$,

$$\frac{g}{V^2} = \frac{0\cdot07241}{(3 + 2\sqrt{2}) \cos H}.$$

The following are some values calculated by means of the formulæ (46) and (47):—

H.	$\frac{g}{V^2}$	s^2	λ.
0°	0·0124	1·025	$0^\circ\ 42'$
45	0·0145	1·029	0 49
90	0·0241	1·048	1 21
135	0·0724	1·145	3 52
180	0·4217	1·843	17 15

In this table λ is the perturbation undergone by the radiant point when observed at the horizon. Nearer the zenith this perturbation is less considerable, and at the zenith it is zero.

The value of s^2 indicates in what proportion the attraction of the Earth, in deviating the meteors, multiplies the number of them which fall upon the Earth.

Let us first pursue the latter inquiry, and see what is the density of the swarm at a place on the Earth situate at n' degrees of distance from the place which has the radiant point at its zenith.

Consider, again, a parallelopiped in the vicinity of the plane P P′ and of the volume $ds \times s\,d\zeta \times d\mathrm{A}$.

The formula (16) gives

$$w_1 w_2 = \sin n' . d\zeta.$$

Then differentiating the formula

$$p = 1 - e \cos (M + n') = 1 - \cos n' + \sin n' \tan M, \qquad (48)$$

which is the formula for the hyperbola, r being put $= 1$; and substituting the values derived from the formulæ (43),

$$dp = \frac{V^2}{g} 2\, s\, ds, \quad d . \tan M = \frac{V^2}{g} ds,$$

we obtain

$$w_1 w_2 = dn' = \frac{V^2}{g} \frac{2s - \sin n'}{\sin n' + \cos n' \tan M} ds, \qquad (49)$$

Lastly, the formula (19) for $r = 1$ gives by means of the formulæ (43) and with the relation $V\,dt = d\mathrm{A}$,

$$dr = \sqrt{1 - s^2 + \frac{2g}{V^2}} . d\mathrm{A}. \qquad (50)$$

The volume of the parallelopiped at the instant of the fall will therefore be

$$w_1 w_2 \times w_1 w_3 \times dr = (2s - \sin n') \sin n' \frac{V^2}{g} \frac{\sqrt{1 - s^2 + \frac{2g}{V^2}}}{\sin n' + \cos n' \tan M} d\zeta \times ds \times dA,$$

and since, by virtue of the formulæ (48) and (43),

$$\sin n' + \cos n' \tan M = \frac{V^2 s}{g} \sqrt{1 - s^2 + \frac{2g}{V^2}}, \qquad (51)$$

we may say that the effect of the attraction of the Earth is to multiply the density of the swarm by a factor

$$f = \frac{s^2}{\sin n' (2s - \sin n')}. \qquad (52)$$

Let us apply to this case the other process of § 2, which consists in calculating in the first instance the parallelogram formed by the Nos. 1, 3, 5, and 7.

We have for the equation of the orbit expressed in rectangular co-ordinates, with the centre of the Earth as origin, and with the axes of x parallel to the asymptote,

$$x^2 + y^2 = (p + x - y \tan M)^2,$$

and differentiating with respect to y, p, and M, and then putting $r = 1$, $x = \cos n'$, $y = \sin n'$, we find

$$dy = \frac{dp - \sin n' \, d.\tan M}{\sin n' + \tan M} = \frac{V^2}{g} \frac{2s - \sin n'}{\sin n' + \tan M} ds, \qquad (53)$$

Differentiating then the same formula with respect to x and y, we have for the same values of r, x, and y,

$$\tan \alpha_1 = \frac{dy}{dx} = \frac{1 - \cos n'}{\sin n' + \tan M},$$

whence for the distance of the two orbits $\tau_1 \tau_5$ and $\tau_3 \tau_7$

$$dy \cos \alpha_1 = \frac{V^2}{g} \frac{2s - \sin n'}{\sqrt{2p + \tan^2 M}} ds = \frac{2s - \sin n'}{s\sqrt{1 + \frac{2g}{V^2}}} ds, \qquad (55)$$

To have the base $\tau_1 \tau_5$ of the parallelogram, we may remark that the primitive velocity is V, and that for the unity of distance is $\sqrt{V^2 + 2g}$; whence

$$dA = V\,dt, \quad \tau_1 \tau_5 = \sqrt{V^2 + 2g} \,.\, dt = \sqrt{1 + \frac{2g}{V^2}} \, dA, \qquad (56)$$

and applying, lastly, the known value of $w_1 w_2$ we shall have for the volume of the parallelopiped at the moment of the fall

$$\frac{1}{s}(2s - \sin n')\sin n'.\ d\zeta\ d\lambda\ ds$$

which leads again to the formula (52).

Let us remark that this formula, for $s = 0$, and consequently $n' = 0$, gives $f = \frac{0}{0}$, an expression of which the value is easily determined. For n' indefinitely small the formula (48) gives

$$\sin n' = \frac{p}{\tan M} = s,$$

and thence

$$f = \frac{s^2}{s^2} = 1.$$

The limit of the places on the Earth which receive the rain of meteors is determined for the value of s^2 in the formula (46) for which (51) gives

$$\sin n' + \cos n' \tan M = 0,\ n' + M = 180°.$$

But from the formula (43)

$$e = \frac{V^2 + g}{g},\ \sin^2 M = \frac{V^2(V^2 + 2g)}{(V^2 + g)^2},\ s \sin M = \frac{V^2 + 2g}{V^2 + g},$$

whence for f in this limiting case

$$f = \frac{(V^2 + g)^2}{V^2(V^2 + 2g)} = 1 + \frac{g^2}{V^2(V^2 + 2g)},$$

a quantity which in general will not differ sensibly from unity.

The last meth od has a particular advantage in that it gives us in the formula (54) an expression for the angle α_1 between the

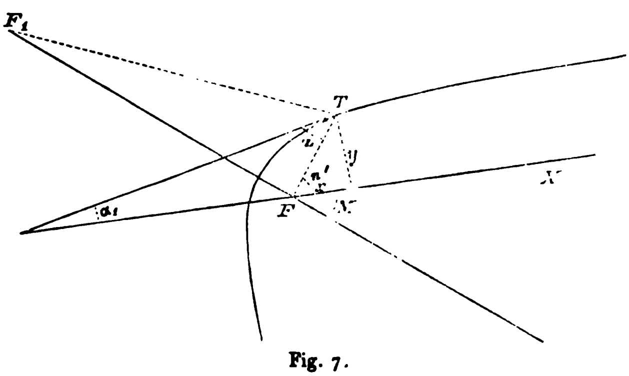


Fig. 7.

asymptote and the direction of motion at the instant of the fall (fig. 7). This angle is therefore the perturbation undergone by

the radiant point for a place on the Earth determined by the angle n'. It will be preferable to express this perturbation as a function of z, the zenith distance of the observed radiant point. Introducing for this purpose the relation $n' = z + \alpha$, the formula (54) becomes

$$\cos z \cos \mathrm{M} = \cos (\alpha_1 + \mathrm{M}), \tag{57}$$

or, replacing M by δ it is

$$\cos z \sin \delta = \sin (\delta - \alpha_1), \tag{58}$$

where the value of δ is give by the formula (44).

We may therefore calculate the perturbation α_1 as soon as we have a relation between z and s_1, a relation which is found in the following manner. Connecting, in fig. 7, the point T with the points F and F_1 we have a triangle the sides of which are 1, $2a + 1$, and $2ae$, and in which the angle opposite to the last-mentioned side is $= 2z$. We have therefore

$$\sin^2 z = \frac{a^2 (e^2 - 1)}{2a + 1} = \frac{ap}{2a + 1} = \frac{s^2}{1 + 2\frac{g}{\mathrm{V}^2}}. \tag{59}$$

To recapitulate we may calculate the correction α_1 of an observed z by the formula

$$s = \sin z \sqrt{1 + \frac{2g}{\mathrm{V}^2}}, \tan \delta = \frac{g}{\mathrm{V}^2 s}, \sin(\delta - \alpha_1) = \sin \delta \cos z, \tag{60}$$

which will serve equally well in the case of an observed s, to calculate successively z, δ and α_1.

For $z = 0$ the formula (60) gives $\alpha_1 = 0$; for $z = 90°$ we have first the formulæ (46) and then $\alpha_1 = \delta$.

The following table gives some values of α_1, for the case $\mathrm{H} = 180°$, that is, $\frac{g}{\mathrm{V}^2} = 0{\cdot}3809$.

z	s	δ	$\delta - \alpha_1$	α_1
°		° ′	° ′	° ′
0	0·0000	90 0	90 0	0 0
15	0·3514	50 12	47 54	2 18
30	0·6788	31 15	27 12	4 39
45	0·9600	23 43	16 32	7 11
60	1·176	19 44	9 43	10 1
75	1·311	17 50	4 33	13 17
90	1·358	17 15	0 0	17 15

I have added a table of some values of f, on the same supposition as to the value of H, calculated by the formulæ

$$a = \frac{g}{\mathrm{V}^2}, \tan \mathrm{M} = \frac{s}{a}, p = \frac{s^2}{a}, \cos (\mathrm{M} + n') = (1 - p) \cos \mathrm{M},$$

$$f = \frac{s^2}{\sin n' (2s - \sin n')}.$$

z	s	M	M + π'	f
°		° ′	° ′	
0	0·0000	0 0	0 0	1·00
15	0·3514	39 48	57 6	1·02
30	0·6788	58 9	92 46	1·03
45	0·6900	66 17	118 29	1·03
20	1·176	70 17	140 13	1·04
75	1·311	72 10	160 25	1·06
90	1·358	72 45	180 0	1·10

§ 5. The preceding paragraphs give the principal features which characterise the phenomenon of a meteoric shower continuing during a year.

In § 3 we have seen how necessary it is to take account of the annual variations presented by the radiant point. Probably it is a less exact proceeding to consider these points as constant during a fortnight or even during two months, as is done in Mr. Greg's chart.

The general formulæ of this paragraph allow us to decide two questions relating to the theory of falling stars.

In the first place, we may ask if the cometary systems contain members of an inferior density, which resolve themselves in our neighbourhood, so as to form there currents of isolated particles. The points of the sphere I. to VII., which I have noticed in vol. xxvii. of the *Monthly Notices*, may be identified in this investigation with the point U of paragraphs 1 and 2.

This calculation has already been made, as an example of the application of the formulæ (41) for the point IV., which is one of those best determined. In comparing the results to the chart, in which Mr. Greg has put a total of 56 radiant points, I find that there are two of these points which may perhaps have the same origin as the Comets of 1857 and 1867.

There is first, point 27, indicated in the following manner:—

$$\begin{array}{lll} \text{May 29 to June 17} & \alpha = 336^\circ, & \delta = 45^\circ, \\ \text{from whence follows} & \lambda = 2^\circ, & \beta = 49^\circ, \end{array}$$

whilst the table given at the end of § 3 indicates for the same interval points R_1 varying between the limits

$$\begin{array}{rl} \lambda = 8^\circ, & \beta = 45^\circ, \\ \text{and } \lambda = 39^\circ, & \beta = 50^\circ, \end{array}$$

and we have, moreover, the point 48,

$$\begin{array}{lll} \text{Oct. 18 to Nov. 3} & \alpha = 83^\circ, & \delta = 12^\circ, \\ & \lambda = 83^\circ, & \beta = -11^\circ, \end{array}$$

whilst the before-mentioned table gives for the same interval points R situated between

$$\lambda = 76^\circ, \quad \beta = -20^\circ,$$
$$\lambda = 88^\circ, \quad \beta = -20^\circ.$$

Certainly I am far from considering this first approximation as a decisive proof, but there is one circumstance which perhaps gives it a little more importance. This is that on November 4th, the Earth, as seen from the Sun, has a longitude of 43°, which is the mean longitude of the ascending nodes of the before-mentioned comets; on May 29th, on the contrary, it had a longitude of 248°, which is nearly the direction of the descending node of the Comet 1867, III.

If, then, the coincidence found is more than mere chance, we should say that in November we ought to meet meteors coming direct from Space; in June, meteors which have already passed their perihelion; but all having the same origin as the cometary system of 1857–1867. But this is a point which requires further investigation.

In the second place, it is an important question if, among the radiant points actually known, there are any which belong originally to the same swarm. To answer this, we may calculate the geometric locus upon the sphere of all the radiant points belonging to the same swarm, to the point U of which we give successively the latitudes 0°, 10°, 20°, 90°. We may represent each of these curves in a map, having the pole of the ecliptic for its centre. Then giving to the curve a rotatory motion about this centre, we would easily recognise, in comparing it with the known radiant points, which of these points may have had a common origin.

I propose to apply the formulæ to these two points of investigation.

In § 4 the necessity of taking account of the Earth's attraction becomes apparent. In the most disadvantageous case the apparent radiant point may have sustained a perturbation of more than 17°. This perturbation, although having an origin entirely different, has much resemblance to the atmospheric refraction. It diminishes the zenith distance, and so much the more as this co-ordinate is larger. In future it will be necessary then to note the hour and the minute of each observation made upon a falling star.

It would be unjust not to mention here that M. Schiaparelli has just published an elaborate Memoir entitled *Note e Riflessioni intorno alla Teoria Astronomica delle Stelle cadenti*, a memoir in which he has devoted an ample discussion to the effects of the terrestrial attraction upon the trajectories of meteors. When I received the copy which the illustrious Italian astronomer has done me the honour of sending me, the greater part of my calculation had been already made. I therefore publish them, at the same time acknowledging the priority of the publication by M. Schiaparelli of some results which appear also in the present Memoir.

Utrecht, January 1868.

Additional Identifications of Double Stars in the Synoptic Catalogues of Sir William Herschel's Micrometrical Measurements &c., with a List of Errata. By Sir J. F. W. Herschel, Bart.

Having been engaged since the communication to this Society of my Synoptic Catalogue of my Father's Double Stars, in entering up the measures therein recorded in their places in a general digest of all the recorded measures of all known double stars (a task begun long ago, and which, though I can never look forward to complete, I hope to leave in such a state of forwardness as will perhaps ensure its completion by some other hand), I have been led by the coincidence, or near coincidence, of the measures with those of stars observed by others, taken in conjunction with so near an approximation of place (when reduced to a common epoch) as to make it matter of reasonable probability that the same object has been brought into the field of view in both telescopes, to the identification, more or less probable, of a considerable number of these stars with those subsequently measured. Under the impression that information of this kind cannot but prove interesting to observers engaged in such measurements, and as supplementing the identifications of a similar kind already embodied in the Memoir above mentioned, I here subjoin a list of the objects in question. Among them occur some few whose places could be assigned only by loose approximation from my Father's allineations, but which now can be stated with precision: by which some trouble will be saved to an observer who might otherwise be disappointed by finding it necessary to sweep for some distance round the assigned place of an object before getting it into his field of view.

In the progress of this work I have been led to the detection of a somewhat formidable list of Errata in the printed Catalogue, which I consider it a duty to communicate, apologising, as best I may, for their occurrence, and making the only amends in my power by pointing them out for correction.

Subsequent additional Identifications more or less probable of Double Stars in the Synoptic Catalogues with each other or with objects observed by other Astronomers.

H. I. 11 is also Wr. 136
I. 13 = Σ. 2545* = S. 790
I. 14 *is* 23 *Aquilæ*, as suggested in col. 12 (nisi)
I. 56 = Σ. 178 = P. i. 191
H. I. 63 = S. 778
II. 63 = S. 553
II. 66 = S. 764
II. 70 = S. 734
II. 86 = Σ. 2016

* I. 13 was assumed as identical with Σ. 2541 on the authority of Struve himself. Mr. Dawes, however, has shown that it is really Σ. 2545: a circumstance which had escaped my recollection; but which is proved to be the fact by the agreement of the measures and the existence of a small companion.

H. II. 97 = S. 775
III. 17 = Sh. 341
III. 37 = Σ. 437 ? ?
III. 38 = Σ. 439 ? ?
III. 46 = III. 114 ?
III. 71 = S. 795
III. 77 = S. 426
III. 80 = S. 412
III. 108 = Sh. 217 *vice* III. 109 ? ?
III. 114 = III. 46 ?
IV. 23 = S. 756 ?
IV. 45 = Sh. 57
IV. 71 = Sh. 324
IV. 92 = S. 759
IV. 127 = Σ. 2434
V. 72 = Sh. 234

H. V. 80 = S. 817
V. 119 = Σ. 734, hardly a doubt.
V. 136 = S. 735
VI. 41 is miscalled by Sh. iv. 41
VI. 87 is miscalled by Sh. vi. 41
H. N. 10 = S. 753
H. N. 11 = Sh. 352
H. N. 13 = Sh. 303
H. N. 33 = Sh. 206
H. N. 36 = Σ. 1466
H. N. 61 = Σ. 1065
H. N. 91 = Σ. 3030 ?
H. N. 105 = Σ. 224 ? ?
H. N. 109 = Sh. 300
H. N. 115 = S. 660 "nova"
H. N. 142 = *Leonis* 339

These identifications, supposing those marked as more or less doubtful (? or ??) verified by future telescopic examinations, will authorize the following more exact places of the stars here numbered in place of those in the Synoptic Catalogue in order of R.A. viz. :—

General No.	Name of Star.	W.H.'s Class and No.	R.A. 1880·0. h m s	Prec. in R.A.	N.P.D. 1880·0 ° ′ ″	Prec. in N.P.D.	Authority.
41	Ceti	I. 56	1 45 40·0	+ 3·18	79 46 56	− 17·9	Σ.P.M.
55	Arietis	IV. 105	2 4 21·7	3·22	76 52 46	− 17·1	Σ.P.M.
97	Persei	III. 37	3 36·5	3·74	58 18	− 11·8	Σ.
98	Persei	III. 38	3 37 2·8	3·74	58 14 0	− 11·8	Σ.P.M.
182	Orionis	V. 119	5 27 3·6	3·03	91 48 7	− 2·8	Σ.P.M.
243 } 245 }	Monocerot.	{ III. 46 / III. 114 }	6 35·6	3·30	80 7·0	+ 3·1	(B.A.C.)
499	Serpentis	II. 86	16 6 28·2	2·81	77 46 43	+ 9·6	Σ.P.M.
609	23 Aquilæ	I. 14	19 12 26·1	3·07	89 7 57	− 6·3	B.A.C.
624	Aquilæ	I. 13	19 32 8·1	3·30	100 25 36	− 7·7	Σ.P.M.
805	Piscium	N. 91	23 34 33·5	+ 3·07	91 2 52	− 19·9	Σ.P.M.

Errata in the Synoptic Catalogue.

Page
25. No. 409, *cols.* 6, 7, *for* 3 31·1 | 70 48 | *read* 3 21 ± | 79 15 ± |
78. *In the heading of col.* 1, *for* Class IV., *read* Class V.
90. *In the heading of col.* 1, *for* Class IV., *read* Class VI.

(In the Synoptic Catalogue by Classes and Numbers.)

Class. No.
I. 3 *in col.* 6, *for* 348·60, *read* 11·40.
I. 13 „ 12, *insert* Triple. A C = 7 or 8″.

Class.	No.		
I.	60	*in col.*	12, *for* 118°, *read* 5°.
I.	70	,,	12, *for* Wr. 90, *read* Wr. 99.
I.	72	,,	12, *for* S. 133, *read* Sh. 133.
I.	87	,,	5, *before* ·381, *insert* 1802.
I.	96	,,	6, *for* 320·05, *read* 326·05.
II.	11	,,	3, *for* Nov. 19, 1781, *read* Oct. 7, 1779.
II.	13	,,	10, *after* 1780·537, *insert* 4·02 ?
II.	21	,,	12, *for* Σ. 1199, *read* Σ. 1999.
II.	91	,,	3, *for* Sagittarii, *read* Sagittæ.
II.	91	,,	12, *after* P. xix. 322 *insert*, erroneously so called by Struve.
III.	2	,,	4, *for* 1782·753, *read* 1802·753.
III.	7	,,	12, *for* Sh. 215, *read* Sh. 217.
III.	13	,,	1, 2, 12, *for* 5 29·0, *read* 5 29·4; *after* Orionis *insert* 133, *and for* Σ. 745, *read* Σ. 747.
III.	14	,,	1, 2, 12, *for* 5 29·4, *read* 5 29·0; *after* Orionis *dele* 133, *and for* Σ. 747. *read* Σ. 745.
III.	19	,,	6, *for* 182·73, *read* 181·44.
III.	49	,,	10, *for* 17·50, *read* 12·50.
III.	50	,,	6, *for* 340·17, *read* 341·17.
III.	51	,,	10, *after* 1783·003, *insert* 14·69.
III.	55	,,	9, *for* 1783·81, *read* 1783·181.
III.	103	,,	10, 11, *insert in the blank spaces respectively* 12·47 *and* 2.
III.	110	,,	8, *for the lower* A B, *read* A C.
IV.	15	,,	12, *for* Σ. 1674, *read* Σ. 1694.
IV.	22	,,	12, *for* Σ.C.P. 706 = 63 Cygni ? *read* Σ. 2743.
IV.	24	,,	6, *for* 45·68, *read* 314·32.
IV.	77	,,	12, *dele* Sh. 73
IV.	85	,,	4 *for the lower* A B, *read* A D.
IV.	132	,,	12, *dele* H N. 62.
V.	89	,,	8, *for* A C, *read* A B.
V.	97	,,	12, *for* V. 121, *read* VI. 121.
V.	99	,,	12, *for* Σ.C.P. 749, *read* Σ. 2900.
V.	121	,,	12, *dele* For two more probable measures of distance, see V. 97.
V.	122	,,	12, *for* Sh. 119, *read* Sh. 189.
V.	131	,,	12, *for* Σ. 476, *read* Σ.C.P. 476.
VI.	121	,,	12, *insert*, For two more probable measures of distance, see V. 97.
H N.	38	,,	2, *for* 15 35·0, *read* 12 35·0.

(*In the Catalogue in order of R.A.*)

Star Nos.		
75, 76,	*col.*	2, *transfer the letter* η *from* Arietis *to* Persei.
186, 189,	,,	2, *after* Orionis *transfer* 133 *from* No. 186 *to* No. 189.
199,	,,	2, *for* 23 Leporis, *read* 13 Leporis.
272,	,,	2, *after* Canis Minoris, *insert* 31.
322,	,,	4, *for* 8 7·1, *read* 8 8·4.
738,	,,	*Note* † *for* 41 23·2, *read* 48 49·2.
795,	,,	*col.* 6, *for* 19 4·1, *read* 99 4·1.
801,	,,	*cols.* 4, 6, 8, *for* 24 45·5, *read* 24·8; *for* 32 6 45, *read* 32 6·8; *and for* B.A.C. *read* (B.A.C.).

Lastly, at the end of the Catalogue add.

Omitted Stars.

No.			h m s	s	° ′ ″	″	
435 *bis*	Bootis	V. 98	14 7 24·0	+ 3·00	84 2 13	+ 17·1	Σ.P.M.
742 *bis*	79 Cygni	VI. 57	21 38 27·8	+ 2·47	52 15 56	− 16·3	B.A.C.
813	Cassiopeæ	V. 79	24 ±	..	unidentifiable	..	..

Collingwood, Feb. 22, 1868.

On the Planetary Nebula 45 H IV. *Geminorum.*
By H. C. Key, Esq.

During the last three years I have constantly observed this remarkable object whenever a favourable opportunity occurred, but until the last few months without any special result. My instrument during that period had been only sufficient to show the star as nebulous, an intervening darker space round the nucleus, and a faint luminous ring at some distance. Since that time my optical means have been considerably increased, and a careful scrutiny has brought to light an additional feature, which seems to have escaped the notice of former observers, and of sufficient interest to induce me to lay it before the Society.

Smyth tells us (*Cycle*, vol. ii. p. 176) that in 1787 Sir William Herschel observed this object, and described it as "a star of the 9th magnitude, with a pretty bright nebulosity, equally dispersed all around;" and he calls it "a very remarkable phenomenon." And that Sir John Herschel describes it as "a star of the 8th magnitude, exactly in the centre of an exactly round bright hemisphere 25″ in diameter."

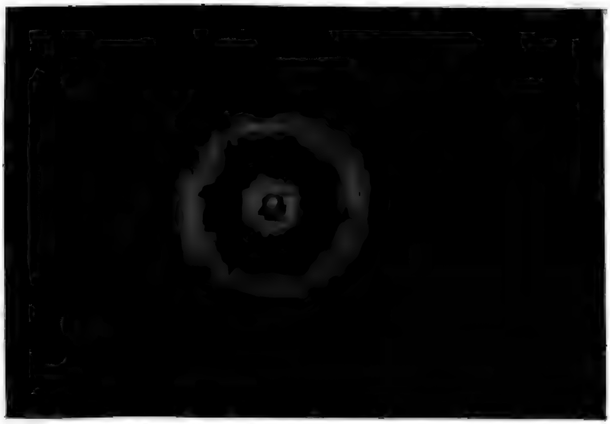
From the Earl of Rosse's account of this object in the *Philosophical Transactions*, 1850, of which Mr. Knott has kindly forwarded me an abstract and rough drawing, it appears that he saw it as a nebulous star with a black patch close to it on the preceding side, a less luminous space, somewhat unequal in breadth, surrounding the nucleus, and a luminous ring at some distance; this ring being of less breadth on the following side.

Mr. Lassell's drawing of this object in 1862 (*Mem. R. A. S.* vol. xxxvi.) represents a star in the centre of a planetary disk, surrounded by a non-luminous space; and, at some distance, by a luminous ring of considerable breadth. He also says, "I can see no trace of the dark patch in Lord Rosse's drawing near the bright centre."

The present appearance of this object, as seen in my instrument, is that of a bright, but somewhat nebulous star closely surrounded by a dark ring; this again by a luminous ring; then

an interval much less luminous, and, finally, at some distance, an exterior luminous ring.

The accompanying drawing (which has been repeatedly verified and corrected), although an inadequate one, if held at such a distance from the eye that the interior bright ring is just seen



45 Ḩ IV. Gem. 18-inch Reflector, power 510.

distinctly detached from the central star, gives a tolerably fair representation of this remarkable object as it appears in my instrument.

The whole is almost exactly symmetrical, although not quite so; the dark space between the two bright rings being darker on the north following side, and the preceding side of the whole object is rather fainter than the rest. Of the two luminous rings the interior is considerably the brightest. Like the annular nebula in *Lyra*, this object bears magnifying wonderfully well: with 150 little more is to be seen than a star in the centre of an extensive gauzelike, nebulous disk; with 300 I detected the interior ring; and 510 I found the most suitable power in every respect; with 666 I did not seem to gain any advantage, but rather the contrary. I may add that I have failed to see anything of the black patch in the Earl of Rosse's drawing, as well as the star shown by Mr. Lassell near the edge of the nebula.

On considering these several observations, which extend over a period of 81 years, from 1787 down to the present time, we can hardly fail to be struck by the progressive character of the results, which seems to be independent of the optical means employed. To both Sir William and Sir John Herschel there appeared merely a uniform nebulous planetary disk surrounding the central star, without any indication of a ring. To the Earl of Rosse, with his enormous optical power, there was visible only one exterior ring, and a small circular dark space near the central star, preceding it. To Mr. Lassell, with scarcely inferior power (comparatively), there was no appearance of an interior

luminous ring. While, in my own instrument, which, although somewhat more powerful than the 20-foot reflectors (front view) of the Herschels, is of incomparably inferior power to the instruments of the Earl of Rosse and Mr. Lassell, the interior bright ring was visible at once during the first night's observation, and with a power of 510 is quite obvious.

Not to draw any very definite conclusions from these results, one fact, at all events, seems abundantly evident,—viz., that whereas at the date of the Herschels' observations there was no appearance whatever of a ring surrounding the central star, at the present time there are two.

The instrument with which my observations were made consists of a silvered glass speculum of 18 inches aperture and 10 feet focal length, of my own making, mounted as a Newtonian equatorially.

I estimated the extreme diameter of the whole object at 35″; and the diameter of the inner ring, taken at its brightest part, at 9″; while its inner diameter I judged to be about 5″.

Stretton Rectory, Hereford,
February 26, 1868.

Postscript, March 23.—Since writing the above I have seen a dark patch situated in the inner dark ring close to the central star. It is a very faint object in my instrument, but I can speak with certainty of its existence; the estimated angle of position is about 5°. I am not aware of the position of the dark patch seen by the Earl of Rosse.

Note on the Occultation of α Tauri on May 22, 1868.

(*Communicated by R. S. Newall, Esq.*)

It may perhaps be desirable to call the attention of observers to the occultation of *α Tauri* on May 22, 1868, because it is not mentioned in the *Nautical Almanack* and other ephemerides on account of its occurring near the time of New Moon. As the star will be about 8° distant from the Sun, there seems little reason to doubt that, in a clear sky, and with a good Equatoreal, the occultation may be observed very well, provided the necessary precautions are not neglected. At any rate, the observation will be worth trying, be it merely as a matter of curiosity, since a similar favourable opportunity of observing an occultation of *α Tauri* so near the Sun will not offer itself again before the year 1885 or 1886.

The elements for computing the occultation beforehand, according to Bessel's formulæ (which may be found in the *Berliner Jahrbuch* and in the *Connaissance des Temps*), are these:—

For Greenwich, Paris, and neighbourhood.	For Washington and neighbourhood.
$T =$ May 22 $6^h\ 50^m{\cdot}0$ Greenwich M.T.	$T = 5^h\ 50^m{\cdot}0$ Greenwich M.T.
$h = 96^\circ\ 5'{\cdot}2$	$h = 81^\circ\ 2'{\cdot}7$
$p = +\ 0{\cdot}6394$	$p = +\ 0{\cdot}0464$
$q = +\ 0{\cdot}6320$	$q = +\ 0{\cdot}5316$

$p' = +0{\cdot}5930$
$q' = +0{\cdot}1003$

The following list contains the local mean times of disappearance and reappearance for a few observations and also the corresponding angles of position Q of the star at the apparent centre of the Moon.

	Disappearance, Local M.T. h m	Q	Reappearance, Local M.T. h m	Q
Berlin	7 20·9	41·3	7 57·4	308·4
Bonn	6 56·0	51·8	7 39·3	298·3
Cambridge, England	6 26·1	53·0	7 11·5	296·6
Cambridge, Mass.	0 37·5	100·4	1 50·6	234·1
Greenwich	6 26·1	55·1	7 12·6	294·6
Liverpool	6 12·3	51·8	6 57·9	297·4
Oxford	6 20·7	55·3	7 7·5	294·4
Paris	6 37·4	60·9	7 25·6	289·4
Washington	0 3·1	108·7	1 12·1	223·5

It need scarcely be mentioned that, in order not to miss the reappearance, the place of emergence will have to be determined with some care. Bessel's expedient, of placing a wire in the direction $Q \pm 90°$, and finding the part of the Moon's limb at which it is a tangent, will perhaps give little trouble at the European observatories, as the reappearance takes place near the middle of the illuminated crescent, where its breadth will be nearly 10″. At the American observatories, where the star reappears near the thin horns of the crescent, the difficulty will be somewhat greater. The direction and distance of the Sun's centre with respect to the star are:

G.M.T.	Angle of Position.	Distance.
6^h	302° 52′·3	8° 10′·9
8	303 15·1	8 7·3

Observations of Planets (94), (95), (96), *and* (97). By Dr. R. Luther.

(94), discovered by Mr. Watson at Ann Arbor. 11.12 magnitude.

	Bilk M.T. h m s	R.A. h m s	Decl. ° ′ ″	
1867, Oct. 25	8 56 16·4	0 20 39·70	+4 35 46·8	13 comp.
26	8 30 49·8	0 20 3·49	+4 34 9·3	10 „
28	9 9 24·5	0 18 51·67	+4 30 55·9	9 „

(95), discovered by myself at Bilk, Düsseldorf. 10.11 magnitude.

	Bilk M.T.	R.A.	Decl.	
	h m s	h m s	° ′ ″	
1867, Nov. 23	9 48 15·7	4 1 32·00	+21 30 17·1	11 comp.
23	11 11 1·6	4 1 28·81	+21 29 53·0	10 ,,
29	8 59 20·0	3 56 24·29	+20 44 47·3	2 ,,
Dec. 3	10 28 32·7	3 53 4·23	+20 13 59·4	12 ,,

The name *Arethusa* was kindly given by Professor Galle and Dr. Günther at Breslau.

(96), discovered by M. Coggia at Longchamp, Marseilles. 11 magnitude.

	Bilk M.T.	R.A.	Decl.	
	h m s	h m s	° ′ ″	
1868, Feb. 28	9 42 35·4	9 23 40·85	+13 29 48·2	8 comp.
	Hourly Motion	−2ˢ in R.A.,	−5″ in Decl.	

(97), discovered by M. Tempel at Marseilles. 10.11 magnitude.

	Bilk M.T.	A.R.	Decl.	
	h m s	h m s	° ′ ″	
1868, Feb. 28	12 37 20·3	11 44 24·26	+4 41 52·5	8 comp.
	Hourly Motion	−2ˢ in R.A.	+25″ in Decl.	

(97) is surely different from (91) *Ægina*.

In the month of January 1868 I have found the following corrections of the Berlin Ephemerides:—

	R.A.	Decl.
	s	′
Parthenope	+3·8	+0·1
Hebe	−0·1	+0·2
Julia	−5·1	+0·2
Ausonia	+0·2	−0·0

Bilk, Düsseldorf, 1868, *March* 4.

Ephemeris of Brorsen's Comet. By Dr. C. Bruhns, Director of the Observatory of Leipzig.

I found with the perturbations of *Jupiter* the following systems of elements from the appearances of 1846 and 1857.

	1846.		1857.		1868.	
T	Feb. 25·406 Berl. T.		Mar. 29·2829 Berl. T.		Apr. 18·4835 Berl. T.	
	° ′ ″		° ′ ″		° ′ ″	
π	126 28 17·1	Mean	115 45 54·3	Mean	116 2 3·1	Mean
☊	102 41 41·3	Equin.	101 47 27·9	Equin.	101 14 5·5	Equin.
i	30 55 16·9	1846·0.	29 48 45·2	1857·0.	29 22 38·5	1870·0.
φ	52 28 23·7		53 17 28·2		53 54 35·6	
M	637″·151		640″·732		647″·0618	

With the latter Elements we obtain for the present appearance the following Ephemeris :—

1868. 0h Berlin T.	α App.	δ App.	Log. Δ	Log. γ
	h m s	° ′		
Mar. 10	1 7 53	− 8 8·5	0·23966	9·97841
11	10 58	7 34·0		
12	14 5	6 58·8		
13	17 14	6 23·0		
14	20 24	5 46·6	0·22708	9·95383
15	23 37	5 9·6		
16	26 52	4 31·9		
17	30 9	3 53·6		
18	33 28	3 14·6	0·21382	9·92837
19	36 50	2 34·9		
20	40 14	1 54·6		
21	43 40	1 13·6		
22	47 9	− 0 31·9	0·19985	9·90233
23	50 40	+ 0 10·5		
24	54 13	0 53·7		
25	57 49	1 37·7		
26	2 1 27	2 22·3	0·18515	9·87614
27	5 8	3 7·7		
28	8 52	3 53·8		
29	12 38	4 40·7		
30	16 27	5 28·4	0·16967	9·85050
31	20 19	6 16·9		
Apr. 1	24 13	7 6·0		
2	28 10	7 56·0		
3	32 9	8 46·7	0·15340	9·82648
4	36 12	9 38·2		
5	40 18	10 30·4		
6	44 27	11 23·3		
7	48 39	12 16·9	0·13635	9·80544
8	52 54	13 11·2		
9	57 12	14 6·2		
10	3 1 33	15 1·9		
11	5 58	15 58·2	0·11853	9·78899
12	10 26	16 55·0		
13	14 58	17 52·4		
14	19 33	18 50·3		
15	24 11	19 48·6	0·10006	9·77875
16	28 53	20 47·3		
17	33 41	21 46·5		
18	38 32	22 46·0		
19	43 27	+ 23 45·6	0·08113	9·77587

1868. 0h Berlin T.	α App. h m s	δ App. ° ′	Log. Δ	Log. γ
Apr. 20	3 48 27	+ 24 45·5		
21	53 32	24 45·5		
22	58 42	26 45·6		
23	4 3 58	27 45·6	0·06207	9·78072
24	9 20	28 45·6		
25	14 50	29 45·4		
26	20 26	30 44·9		
27	26 7	31 44·0	0·04336	9·79271
28	31 56	32 43·0		
29	37 54	33 41·3		
30	44 0	34 39·1		
May 1	50 16	35 36·2	0·02546	9·81050
2	56 41	36 32·5		
3	5 3 16	37 27·8		
4	10 2	38 22·1		
5	16 59	39 15·4	0·00895	9·83246
6	24 7	40 7·4		
7	31 27	40 58·1		
8	39 0	41 47·3		
9	46 46	42 34·8	9·99440	9·85701
10	54 45	43 20·5		
11	6 2 57	44 4·3		
12	11 23	44 46·0		
13	20 1	45 25·4	9·98229	9·88287
14	28 53	46 2·4		
15	37 59	46 36·9		
16	47 16	47 8·8		
17	56 45	47 37·8	9·97313	9·90909
18	7 6 26	48 3·8		
19	16 16	48 26·6		
20	26 14	48 46·3		
21	36 19	49 2·8	9·96724	9·93502
22	46 30	49 15·8		
23	56 46	49 25·3		
24	8 7 4	49 31·4		
25	17 22	49 34·1	9·96488	9·96027
26	27 38	49 33·4		
27	37 52	49 29·3		
28	48 2	49 21·7		
29	58 6	+ 49 10·7	9·96615	9·98460

14 *March*, 1868.

*Description of a Zenith Telescope.** By J. Simms, Esq.

I have been requested by several members of the Society to describe this Zenith Telescope, with the view of bringing forward a method of determining the latitude which has been for several years generally adopted by the United States Coast Survey, and which not only has the advantage of being simple, but also when the places of the stars made use of have been well ascertained, is extremely accurate.

The instrument is supported upon a strong tripod having feet screws for levelling; to this tripod is fixed the azimuth circle and also the fixed vertical axis. A hollow axis which serves to support the upper part of the instrument, moves upon the fixed axis. The upper part consists of a telescope, fixed to the end of a horizontal moveable axis, so that, in fact, the movements are those of an altazimuth. An extremely sensitive level is fixed to the telescope which also carries a micrometer with a screw of long range. There is a peculiarity in this instrument in the manner of bringing the weight of the upper part over the centre of the upright pillar, which deserves notice. In order to accomplish this, and at the same time to avoid the flexure which would be caused by the overhanging position of the telescope, a steel lever having its fulcrum over the centre of the instrument is, by a bend, passed round to the front of the telescope, where it supports a small pivot which is really a continuation of the horizontal axis, the other end of the lever carries a counterpoise.

The Zenith Telescope in its present form was arranged by Würdermann of Washington, U.S.

In Pearson's *Astronomy* may be seen represented two varieties of Zenith Telescope, one of which has the level and micrometer of Würdermann's instrument, whilst the other possesses the horizontal axis, it wonld thus appear that the modern form is a combination of two previously existing models.

The method of observation is known as Talcott's, it is described in the U. S. Coast Survey Report for 1857.

Two stars are selected, one of which passes the meridian to the north, and the other at nearly the same distance to the south of the zenith. The telescope is brought into the plane of the meridian and set for the star which first passes the meridian; when visible it is bisected by the micrometer wire, the tangent screw of the instrument being used. The telescope is then turned 180° in azimuth, and when the second star makes its appearance, should there be any difference in the zenith distances, this difference is measured by the micrometer screw.

It is evident that, having the sum of the zenith distances as given by the Catalogue, and having obtained the difference by means of the instrument, the latitude may be readily deduced therefrom.

* Exhibited at the Meeting. Ed.

D

Should the position of the level vary between the two observations, a correction will have to be applied; refraction may, in general, be neglected, as the difference in the refraction of the two stars (in most cases a very small quantity) is that which alone has to be regarded.

From a paper by the late Mr. Pond, Astronomer Royal, read before the Royal Society, March 13, 1834, entitled "Some Suggestions relative to the best method of employing the New Zenith Telescope lately erected at the Royal Observatory," it would appear that he suggested and made use of this mode of observing: this paper appears to have been generally lost sight of.

The Great Nebula in Orion. By Father A. Secchi.

I take the liberty of presenting to the Royal Astronomical Society a drawing of the great Nebula of *Orion*, which was commenced several years ago, and finished last year by combined observations made by myself and Padre Ferrari, my assistant. Last autumn some copies of it were distributed to friends, but not as definite specimens. Lately I have re-examined this object and found the figuring correct, as seen on dark nights in our 9-inch refractor. But upon observing it in moonlight, I was surprised at the amount of details which then came out. I resolved, therefore, to take advantage of this circumstance, and to introduce these details into the drawing, making the observations in different phases of the Moon to obtain a more distinct graduation of light.

The present drawing embraces these results, which will, I hope, prove interesting. It may appear extraordinary that we should see such an object better in moonlight, but this is not very surprising, since it is only a consequence of that optical principle, that the difference of two lights is more easily appreciated when they are weak than when they are both very strong. This, therefore, is a case like that of the spots on *Venus*, which are better seen in daylight than at night, and of the bands of *Jupiter*, which are better seen in twilight than in complete darkness. I, consequently, hope that this drawing will not be useless, even after the great work of Lord Rosse; and it will at least show how much may be seen with an instrument of comparatively limited power, and that some information may thus be obtained respecting the influence caused by the aperture, and the amount of light of the instrument.

As I have not yet received the *Philosophical Transactions* I have not been able to compare my results with those of Lord Rosse. I saw his lordship's drawing at Sir John Herschel's last October, and I then found that the principal masses in my drawing agreed with it; I therefore hope that these minor details may in like manner agree.

As regards the spectrum of the Nebula, I have nothing to add, except that I have made an experiment which may explain why we see only one of the three hydrogen lines in the Nebula. Having obtained by a Geissler tube a good spectrum of pure hydrogen with the three characteristic lines, I found that, by diminishing the light by reflexion on a glass plate, the two lateral ones disappeared, the middle line only remaining, which is that visible in the Nebula. The simple diminution of the light may therefore account for the other two lines of this gas not being visible. I think, therefore, that it would be of great interest to have this Nebula observed in Southern regions with a larger instrument in order to ascertain, if possible, whether the other two lines can thus be rendered visible.

Extract of a letter from Father Secchi to Admiral Manners:—

"*Rome, March* 27, 1868.

"I am busy about the spectrum analysis of stars, and you will see in the *Comptes Rendus* a very advantageous method of determining the motion of the stars in space by the spectrometer. I, however, require a larger instrument, because a 9-inch object-glass is rather too small for this purpose. I have greatly improved the direct view spectroscope, so that it has become a very suitable instrument. I have introduced an eye-piece, made completely with cylindrical lenses, which is exceedingly powerful, and leaves a great deal of light. I have examined almost the whole of the Red Stars in the Catalogue of M. Schellerup, and have arrived at some very interesting conclusions. All these red stars have spectra, either furnished with bands and striæ like α *Orionis*, or like the star *Lalande* 12561, figured in my second map of the Memoir, which I have sent to the Society. As soon as the full review is finished, I will send the complete Catalogue to the Society, with figures and description.

"I have since studied the spectrum of α *Orionis* more accurately, and it seems to me that the hydrogen lines exist even in it. I have got a very good spectroscope, with a double prism, by Hoffman, and some wonderful prisms by M. Merz: with one of these I can see as many lines in the solar spectrum, as Bunsen saw with his four prisms.

"I have made a *resumé* of all the measures of double stars taken since my last publication in 1859, and in number they amount to 158 objects, the greater part of them periodical, and many of them have changed their position since my last measures, and those of Struve."

The Rev. W. R. Dawes, died February 15, at Haddenham, aged 68 years.

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// MONTHLY NOTICES

OF THE

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Admiral MANNERS, President, in the Chair.

W. Lloyd Wise, Esq., Greenhythe,
was balloted for and duly elected a Fellow of the Society.

On the Rejection of Discordant Observations.

By E. J. Stone, Esq.

In the discussion of the results of observation there is nothing more unsatisfactory than the necessity, which occasionally arises, for the rejection of certain results because of their discordance with the general average given by numerous observations. These discordant results will in many cases be found to be deduced from observations made by observers of great experience and skill, and apparently under most favourable circumstances. In such cases our minds are almost irresistibly led to assume that causes of error must have been in action other than those causes which lead to the ordinary graduated errors. It is clear, however, that such assumption of irregular causes must not be made without great caution and reserve. So far as I know only two criteria for the rejection of apparently anomalous results have been published. In No. 45 of Dr. Gould's *Astronomical Journal*, Professor Peirce has published an investigation leading to formulæ of some complexity for the rejection of such observations. The employment of these formulæ is rather troublesome, and grave doubts have been expressed with respect to the accuracy of the

heory upon which they are based. See Airy, No. 90 of Gould's *Astronomical Journal.*

In Chauvenet's most valuable *Treatise on Astronomy*, vol. ii. page 565, will be found a simple criterion for the rejection of one observation. This criterion is introduced ostensibly for the purpose of clearing up certain difficulties in the understanding of Peirce's criterion. Chauvenet's criterion may be stated as follows:—

If $\theta(x)$ denote the probable number of errors equal to or greater than x, when the whole number of observations is denoted by unity, then the number of errors equal to or greater than x, which may fairly be expected in n observations is $n\,\theta(x)$. If therefore we find x such that $n\,\theta(x) = \frac{1}{2}$, any error greater than x will have a greater probability against it than for it, and may, therefore, be rejected.

This criterion appears to me to be based on an erroneous principle. In $2\,n$ such observations we ought reasonably to expect one error equal to or larger than x. In n observations therefore we ought not to be surprised at the appearance of such an error, and certainly its appearance would be no fair ground for an assumption of some disturbing cause of error.

I have been led, on consideration of this subject, to a formula which embodies, in my opinion, the true grounds upon which my judgment rests when compelled to reject discordant observations.

If a is the ordinary probability parameter of a class of observations, we have for the probability of an error equal to or greater than p,

$$\frac{2}{\sqrt{\pi}}\int_p^\infty \epsilon^{-\frac{x^2}{a^2}}\,\frac{dx}{a},$$

or if $y = \frac{x}{a}$, the probability

$$= \frac{2}{\sqrt{\pi}}\int_{\frac{p}{a}}^\infty \epsilon^{-y^2}\,dy.$$

As a matter of fact, we know that *mistakes* do occur in the making and registering of observations. To confine our attention, for example, to observations in zenith distance, the observer may omit to clamp the circle and the instrument may be moved between the bisection of a star and the reading of the microscopes. He may clamp the circle inadvertently, after having made his bisection. He may bring the declination wire nearly to bisect the star, with the intention of completing the bisection at the centre of the field, and then forget to make the bisection. He may accidentally touch the declination screw, or micrometer heads, after the bisections have been made and before the read-

ings have been registered. He may read off wrongly the heads of his micrometers or transpose his readings in entering them in the observing book; or he may enter erroneously the readings of the barometers or thermometers required for the calculation of the refraction corrections. These, and possibly other, errors we know that an experienced and careful observer may make in entire ignorance of there being anything wrong in his work. We have here a series of causes of errors entirely distinct from those which lead to the ordinary graduated errors.

For a given class of observations and for a given observer there must exist a number n, which expresses the average number of observations which that person makes with one mistake. n may be defined as the modulus of carelessness.

If, therefore, we find that value of p, which makes

$$\frac{2}{\sqrt{\pi}}\int_{\frac{p}{a}}^{\infty} \epsilon^{-y^2}\, dy = \frac{1}{n},$$

all larger values of p are, with greater probability, to be attributed to mistakes than to the ordinary run of graduated errors. Larger values of error than p must therefore be rejected. If e denote the probable error of an observation, we have

$$e = 0{\cdot}4769 \times a,$$

our equation for the determination of p becomes therefore

$$\frac{2}{\sqrt{\pi}}\int_{p\,\frac{0\cdot4769}{e}}^{\infty} \epsilon^{-y^2}\, dy = \frac{1}{n}.$$

From which, so long as n remains constant, we see that the limit of rejection varies directly as the ordinary probable error.

The following table gives the limits of rejection, with a probable error $0''{\cdot}477$, for different values of the modulus of carelessness n. It may be mentioned that the assumed probable error is about that of a Greenwich observation of *Polaris* in N.P.D.

Value of n.	Limit of Rejection.
	"
5	0·95
10	1·2
20	1·4
40	1·6
80	1·8
100	1·9
1000	2·3
10000	2·7

If this theory is correct, the meaning of these numbers is as follows. Suppose we are satisfied that on an average our observer makes one mistake in a thousand observations. I mean such a mistake as cannot be detected and corrected with perfect, or almost perfect certainty. Then, with a probable error of $0''.477$, all discordances, from the mean of a great number of observations, greater than $2''.35$, should be at once rejected.

Discordances so large as $2''.75$ should not be retained unless we are prepared to believe that our observer only makes one mistake in making and registering 10,000 observations. Discordances so small as $0''.95$ ought not to be rejected unless we are prepared to believe that, on an average, our observer makes one mistake in five observations. It is perhaps impossible to determine the absolute value of n for any class of observations, but an inspection of the tables shows that the limit of rejection varies very slowly for any values of n which would be admissible in the case of observations made by careful and experienced persons. A rough value of n is quite sufficient for practical purposes, but when once a value of n is admitted, all rejections are determinate. If this theory is correct our rejection cannot be made, except upon a direct admission of carelessness.

The following table would give, according to this theory, the limits of rejection for different probable errors with an assumed value of $n = 500$:—

Probable Error.	Limit of Rejection.
$''$	$''$
0·12	0·55
0·48	2·2
0·95	4·4
1·91	8·8
3·82	17·6

or very roughly about five times the probable error.

Note on the Employment of the Table given in the Nautical Almanac, "showing the Correction required on account of Second Differences in finding the Greenwich Time corresponding to a reduced Lunar Distance." By Capt. Shadwell, R.N.

Finding the time corresponding to a reduced lunar distance is effected by the inverse application of the general formula of interpolation

$$F_{(n)} = F + n\,a' + \frac{n\,.\,\overline{n-1}}{1\,.\,2}\,b' + \&c.$$

whence, transposing and disregarding the second differences, we have as a first approximation

$$n_1 = \frac{F_{(n)} - F}{a'}, \qquad (1)$$

and again, as a more correct result, taking account of the second differences,

$$n_2 = \frac{F_{(n)} - F}{\left(a' + \frac{n_1 - 1}{2} b'\right)}. \qquad (2)$$

The lunar distances being registered in the ephemeris for every three hours, $n_1 = \frac{t^h}{3^h}$, $n_2 = \frac{t'^h}{3^h}$; also $F_{(n)} - F = \Delta'$, the partial difference between the given lunar distance and the one which next precedes it in the Table; hence we have

$$t = 3^h \times \frac{\Delta'}{a'},$$

and in logarithms

$$\log t = \log \Delta' + P \log a',$$

and similarly

$$\log t' = \log \Delta' + P \log \left(a' - \frac{3^h - t}{3^h} \frac{1}{2} b'\right).$$

The proportional logarithm of a' (the difference between the consecutive values of the distance) is given in the ephemeris; denoting this by Q, and the difference between it and the one which next follows it by Δ Q, we have

$$\left.\begin{aligned} \log t &= \log \Delta' + Q, \\ \log t' &= \log \Delta' + \left\{ Q - \frac{3^h - t}{3^h} \frac{1}{2} \Delta Q \right\}, \end{aligned}\right\} \qquad (3)$$

in which we should employ an interpolated value of the proportional logarithm, and assume that the variation of Q is proportional to the corresponding change in a', which is very nearly true.

Or again, wholly employing proportional logarithms,

$$\left.\begin{aligned} P \log t &= P \log \Delta' - Q, \\ P \log t' &= P \log \Delta' - \left\{ Q - \frac{3^h - t}{3^h} \frac{1}{2} \Delta Q \right\}, \end{aligned}\right\} \qquad (4)$$

by which first t, and then t', might be obtained.

It is usual however in practice only to find the approximate interval t, from the above equation, and then to determine the cor-

rection $t'-t$ by aid of a subsidiary table, which is obtained in the following manner.

Subtracting the first equation in (3) from the second, we have

$$\log t' - \log t \text{ or } \log \frac{t'}{t} = - \frac{3^h - t}{3^h} \frac{1}{2} \Delta Q.$$

But by the properties of logarithms,

$$\log \frac{t'}{t} = M \frac{t'-t}{t} \text{ very nearly,}$$

$\frac{t'-t}{t}$ being necessarily a very small fraction; M being the Modulus of our system of common logarithms 0·434294.

Hence by substitution in the above

$$M \frac{t'-t}{t} = - \frac{3^h - t}{3^h} \frac{1}{2} \Delta Q,$$

whence

$$t' - t = - \frac{t \,.\, (3^h - t)}{2 \times 3^h \times M} \Delta Q,$$

which gives the correction in units of an hour, or expressing it in seconds,

$$(t'-t)^s = - \frac{t^m (180 - t^m)}{2{\cdot}605764} \Delta Q$$

$$= - t^m (180 - t^m) \; [\bar{1}{\cdot}584064] \, \Delta Q \qquad (5)$$

From this formula (5) the table given in the *Nautical Almanac* and other works* is computed; the arguments being the approximate interval t expressed in minutes, and the *significant* figures of the difference of the proportional logarithms, Δ Q.

It is customary, and in accordance with the precepts given in the *Nautical Almanac* (Annual Explanation) and other works, to use the difference between the two proportional logarithms standing opposite to the two distances, which include the given distance, as Δ Q; this is equivalent to the employment of the second difference, b', in equation (2), and only takes into account the second difference which follows the function F from which we set out, taking no account of the second difference obtained by considering the values of the functions which precede it; the result is that the time obtained is *over-corrected* when the proportional logarithms are *increasing*, and *under-corrected* when they are *decreasing*, the second differences having in fact been assumed as constant when they may really not be so.

* Norie, Table LIV.; Raper, Table, 57, &c.

When there is great irregularity of variation in the successive values of the lunar distances, this circumstance may produce a very sensible error in the resulting time.

This defect can however be remedied in a very simple manner by employing the formula attributed to Bessel, and using the *mean* second difference $b_0 = \frac{b' + b}{2}$ instead of b' as before, that is to say, by deducing the correction from the formula

$$F_{(n)} = F + n\,a' + \frac{n \cdot n - 1}{2}\,b_0.$$

This would be effected in using the table by employing as the argument "difference of proportional logarithms," *not* the difference between the proportional logarithms standing opposite the distances in the ephemeris which include the given distance, but the *mean* of this difference and the one which precedes it.

Thus, suppose the given distance for which the time is required fell between 9^h and midnight, we should use the *mean* difference between the proportional logarithms standing against 6^h and 9^h, and 9^h and midnight, and so on, in like cases.

Example 1. Required the Greenwich mean time corresponding to the Moon's distance from Fomalhaut, $31^\circ\ 42'\ 57''$, on Nov. 6, 1864. (From the *Nautical Almanac*, 1864, Explanation, p. 521.)

In this case the given distance falls between the distances in the *Almanac* at IX^h. and midnight, the approximate interval is found to be $1^h\ 28^m\ 52^s$.

The "difference of prop. logs" at IX^h. and midnight is 235, from which and the "approximate interval," $1^h\ 30^m$, we get as the correction 89^s to be subtracted, and finally the G.M.T. becomes $10^h\ 27^m\ 23^s$.

A rigorous solution of the example by the formula of interpolation, using the *mean* second difference b_0, gives the G.M.T. $10^h\ 27^m\ 31^s{\cdot}5$, which differs from the *Nautical Almanac* result by $8^s{\cdot}5$, or a little more than two miles of longitude.

Again, the "diff. prop. log." at VI^h. and IX^h. is 242, and between IX^h. and midnight 285, the *mean* of which is 263. Using this as the argument of the table, we get the correction 81^s, which gives the corresponding G.M.T. $10^h\ 27^m\ 31^s$, agreeing with the above result by a rigorous computation.

Example 2. Required the Greenwich mean time corresponding to the Moon's distance from *Pollux* $18^\circ\ 5'\ 2''$ on February 14, 1867. (From the Explanation, *Nautical Almanac*, 1867, p. 528.)

Here the approximate interval comes out $1^h\ 30^m.10^s$, the distance lying between XV^h. and $XVIII^h$., and the "difference of the prop. logs" at those times is 247, from which and the "approximate interval" $1^h\ 30^m$, the table gives the correction 78^s to be subtracted, whence finally the G.M.T. becomes $16^h\ 28^m\ 52^s$.

A rigorous solution by the formula of interpolation gives the

G.M.T. $16^h\ 29^m\ 4^s{\cdot}5$, which differs from the *Nautical Almanac* result by $12^s{\cdot}5$, which is equivalent to three miles of longitude.

Again, the "diff. prop. logs" at XV^h. and $XVIII^h$. is 247, while between midnight and XV^h. it is 186, hence the *mean* difference is 216. Using this as the argument of the table we get the correction 68^s, which applied to the approximate G.M.T. gives finally $16^h\ 29^m\ 2^s$ as the corrected time, which result agrees much more nearly with that obtained by a rigorous application of the formula before mentioned.

It may possibly be objected that these are extreme cases, and that the cases involved will not generally be so large; this may no doubt be true, but as the mode of rightly employing the table only involves a very simple change of procedure, there seems to be no good reason why it should not be adopted.

Haslar, March 20, 1868.

Occultations of Stars by the Moon, and Phenomena of Jupiter's Satellites, observed at the Royal Observatory, Greenwich, from January to December, 1867.

Occultations of Stars by the Moon.

Day of Obs. 1867.	Phenomena.	Moon's Limb.	Mean Solar Time. h m s	Observer.
May 6	(a) 117 Tauri disapp.	Dark	8 3 56·5	C.
	117 Tauri, reapp.	Bright	8 40 52·4	C.
June 14	49 Libræ, disapp.	Dark	12 31 15·7	J. C.
Nov. 6	(b) Aquarii, disapp.	Dark	10 28 17·7	J. C.
8	10 Ceti, disapp.	Dark	7 7 0·5	E.

(a) Extremely faint: the observation doubtful perhaps to a second or two.
(b) Cloudy. The time noted by the observer has been increased by one minute.

Phenomena of Jupiter's Satellites.

Day of Obs. 1867.	Sat.	Phenomena.	Mean Solar Time. h m s	Observer.
June 14	III.	Occult. reapp. bisection	14 27 4·4	J. C.
28	III.	Eclipse, disappearance	13 32 46·5	D.
July 9	III.	(a) Transit, ingress, bisec.	12 0 11·7	K.
10	IV.	Eclipse, reappearance	13 43 28·6	E.
Aug. 10	III.	Eclipse, disappearance	13 37 34·5	D.
Sept. 5	I.	Occult. disapp. first cont.	10 41 37·2	J. C.
	I.	,, ,, bisection	10 43 21·9	J. C.
	I.	,, ,, last cont.	10 45 36·6	J. C.
5	I.	Eclipse, reappearance	13 17 26·8	J. C.

Day of Obs. 1867.	Sat.	Phenomena.	Mean Solar Time. h m s	Observer.
Sept. 6	I.	Transit, ingress, bisec.	7 58 44·3	K.
	I.	" " last cont.	8 1 3·9	K.
15	III.	(*b*) Occult. disapp. first cont.	7 27 1·2	J. C.
	III.	" " bisection	7 30 30·6	J. C.
	III.	" " last cont.	7 34 0·0	J. C.
	II.	Eclipse, reappearance	8 58 44·2	J. C.
	IV.	Occult. reapp. bisection	9 31 10·9	J. C.
	IV.	" " last cont.	9 35 10·3	J. C.
	IV.	Eclipse, disappearance	10 0 11·2	J. C.
	IV.	(*c*) Eclipse, reappearance	14 23 53·2	J. C.
20	I.	Transit, ingress, first cont.	11 23 2·0	H. C.
	I.	" " bisection	11 25 3·7	H. C.
	I.	" " last cont.	11 27 41·3	H. C.
21	I.	Occult. disapp. bisection	8 39 38·1	E.
22	III.	Occult. disapp. first cont.	10 47 47·8	L.
	III.	" " bisection	10 50 17·4	L.
	III.	" " last cont.	10 52 17·0	L.
	II.	Eclipse, reappearance	11 34 49·6	L.
Oct. 1	II.	Transit, egress, bisection	7 26 49·9	P.
	II.	" " last cont.	7 29 4·6	P.
10	III.	Transit, ingress, first cont.	7 45 33·0	K.
	III.	" " bisection	7 49 7·4	K.
	III.	" " last cont.	7 52 2·0	K.
	IV.	Transit, egress, bisection	10 4 54·8	K.
	IV.	" " last cont.	10 10 3·9	K.
	III.	Transit, egress, bisection	11 26 36·4	K.
	III.	" " last cont.	11 29 40·9	K.
17	II.	(*d*) Eclipse, reappearance	8 39 51·9	H. C.
28	III.	Occult. reapp. bisection	8 21 31·7	J. C.
	III.	" " last cont.	8 23 31·4	J. C.
	III.	Eclipse, disappearance	9 55 56·0	J. C.
Nov. 2	II.	(*e*) Transit, egress, bisection	6 25 41·8	J. C.
	II.	" " last cont.	6 28 41·3	J. C.
6	I.	Occult. disapp. bisection	8 32 14·0	J. C.
	I.	(*f*) " " last cont.	8 35 13·6	J. C.
7	I.	Transit, egress, last cont.	8 1 18·8	C.
8	I.	Eclipse, reappearance	6 38 28·4	E.
11	II.	Eclipse, reappearance	5 48 44·8	C.
23	I.	Transit, egress, first cont.	6 18 48·6	C.
	I.	" " last cont.	6 20 18·3	C.
Dec. 7	I.	(*g*) Transit, ingress, first cont.	7 56 3·2	C.

(*a*) The image blurred; the observation uncertain. (*b*) The image of the anet very tremulous and diffused. (*c*) The image very bad. A little uncertain

in consequence of the satellite reappearing close to the third satellite. (*d*) Very uncertain: appeared very near the third satellite. (*e*) The satellite faint: the planet badly defined. (*f*) The image of the planet very ill defined and tremulous. (*g*) The image of the planet very bad.

The initials D., E., C., L., J.C., K., and H.C., are those of Mr. Dunkin, Mr. Ellis, Mr. Criswick, Mr. Lynn, Mr. Carpenter, Mr. Kerschner, and Mr. H. Carpenter.

A Synoptical Catalogue of known and suspected Binary Stars. By G. F. Chambers, F.R.A.S.

About a year and a half ago, an able working astronomer whose name is by no means so well known to the Society as it should be, Mr. A. Brothers, F.R.A.S., of Manchester, presented to the Manchester Literary and Philosophical Society a very carefully prepared catalogue of known and suspected binary stars. Extending as it did, with the introduction, over twenty-seven closely-printed pages, it will readily be inferred that it was of a somewhat elaborate character; and such, indeed, was the case, for of some of the stars as many as twenty sets of measures by all the leading observers were given.

An abstract of this catalogue, kindly prepared for me at very short notice, was afterwards published in my *Descriptive Astronomy*, but as in the said abstract the places were not brought up to any uniform epoch, and as there were other defects in it which it is not worth while to particularise, I decided to take an early opportunity of computing all the places for the one epoch of 1870, and of re-writing the catalogue generally, with such textual revision as seemed necessary to bring it down to the present state of our knowledge. With this end in view, I have carefully collated all recent publications, including especially the valuable memoir of Mr. Dawes, just published,—his last legacy to us.

It does not occur to me that it is necessary to say much else by way of introduction. All the data have been selected from the latest and most trustworthy sources, and no pains have been spared to make the catalogue all that it should be.

The signs + and — in the last two columns indicate, it need hardly be said, that the position angle or the distance is increasing or diminishing as the case may be. A note of interrogation (?) denotes probability without certainty, but ± ? means that it is wholly impossible, owing to the discordances in the measures, to pronounce an opinion one way or the other.

A star (*) is prefixed to various objects of which I have been unable to discover any recent measures. It may therefore be taken that new measures of these are much wanted.

Part I. Known Binary Stars.

of Star.	Struve's No.	R.A. 1870. h m s	Decl. 1870. ° ′	Epoch 1880 +	Mag.	Position. °	Distance. ″
phei	2	0 2 11	+78 56·2	65·7	5½, 6	295·5−	[0·38−]
phei	13	0 8 53	+76 10·3	63·0	6, 6½	103·5−	0·50 −
æ	60	0 41 15	+57 7·8	65·7	4, 7½	125·6+	6·75 −
medæ	73	0 47 59	+22 55·5	66·0	4, 6½	349·5+	1·31 +
Piscium	..	0 52 44	+ 0 4·9	52·8	8, 9	305·1+	18·80 ±?
	113	1 13 9	− 1 11·5	63·0	6, 7½	343·0+	1·27 + ?
Piscium	138	1 29 15	+ 6 58·8	63·1	7, 7	28·7+	1·57 ±?
. Piscium	186	1 49 10	+ 1 12·1	63·8	7½, 7½	85·1+	0·30 −
	202	1 55 18	+ 2 8·1	65·7	5, 6	325·7−	3·23 −
nedæ B.C.	..	1 55 55	+41 42·4	65·7	5, 6·3	107·0−	0·59 ±?
dromedæ	228	2 5 43	+46 52·9	62·9	7, 7	286·5+	0·90 −
rsei	257	2 15 53	+60 57·7	63·1	7, 8	183·5+	[0·40−]
æ A B	262	2 18 22	+66 49·0	62·9	4½, 7	265·8−	1·92 − ?
ssiopeæ	278	2 26 26	+68 43·7	57·9	8, 8½	67·6−	0·40 ±?
ietis	305	2 40 9	+18 48·5	63·0	7, 8	321·7−	2·52 +
	333	2 51 46	+20 49·2	66·6	6, 6½	199·6+	1·14 +
. B	412	3 26 44	+24 1·7	65·7	7½, 7½	240·8−	0·50 −
Eridani	..	3 30 7	+ 0 9·8	45·8	6½, 9	235·9+	6·00 +
	460	3 48 23	+80 19·8	62·9	5½, 6½	15·6+	0·70 −
melopardi	511	4 7 1	+58 4·2	63·6	6, 7	294·7−	..
uri	535	4 16 14	+11 1·3	63·0	7, 8	342·3−	1·73 ±?
pardi	566	4 29 39	+53 12·9	63·2	5½, 8½	299·5−	1·68 ±?
urigæ	577	4 33 28	+38 15·2	62·7	7½, 8	265·5−	1·62 + ?
minorum	932	6 26 41	+14 50·8	63·4	8, 8½	333·2 −	2·26 ±?
, A B	948	6 34 44	+59 34·2	66·2	6, 6½	136·5−	1·64 +
Iajoris	..	6 39 25	−16 32·4	66·2	1, 10	70·3−	10·10 −
orum	982	6 47 18	+13 20·6	66	5½, 8	164·7−	5·70 −
emin.	1037	7 4 42	+27 26·7	63·2	7, 7½	318·1−	1·22 ±?
rum	1110	7 26 18	+32 10·4	65·3	3, 3½	241·4−	5·68 +
Ionoc.	1157	7 48 1	− 2 27·5	63·1	8, 8¼	256·7−	1·29 −
cis	1187	8 1 20	+32 36·3	66·1	7, 7½	56·3−	1·83 +
A B	1196	8 4 45	+18 2·4	66·2	6, 7	234·6−	0·40 −
A C	..	..	..	66·2	6, 7½	140·7−	5·61 −
	1273	8 39 53	+ 6 53·8	66·1	4, 8½	213·8+	3·87 ±?
ncis	1338	9 12 48	+38 44·2	66·1	6½, 7	142·5+	1·71 ±?
	1356	9 21 29	+ 9 37·3	66·3	6½, 7¼	32·9+	0·30 −
. Sext.	1377	9 36 42	+ 3 13·3	56·2	8, 10	129·4−	3·11 − ?
Iajoris	..	9 43 14	+54 40·2	66·4	5, 5¼	45·9+	0·24 −
is	..	9 46 4	− 7 29·5	60·3	6, 6½	38·2−	0·50 ±?
	1424	10 12 47	+20 30·1	66·2	2, 4	111·4+	3·17 +
onis	1426	10 13 43	+ 7 5·0	56·1	7½, 8	271·7+	0·65 ±?

No.	Name of Star.	Struve's No.	R.A. 1870. h	m	s	Decl. 1870. °	′	Epoch 1880+	Mag.		Position. °	Distan. ″
42	1457 Σ. Sextantis	1457	10	31	55	+ 6	24·9	63·2	7½,	8½	309·8 +	0·91 +
43	1516 Σ. Draconis	1516	11	6	28	+74	11·7	63·3	7,	7½	70·0 +	4·14 +
44	ξ Ursæ Majoris	1523	11	11	15	+32	16·0	66·3	4½,	5½	86·5 —	2·25 -
45	ι Leonis	1536	11	17	8	+11	14·9	65·4	4,	7½	72·1 —	2·81 +
46	191 B Virginis	1647	12	24	0	+10	45·7	63·2	7½,	8	212·9 +	1·39 +
47	γ Virginis	1670	12	35	5	— 0	44·2	66·3	4,	4	164·2 —	4·39 +
48	1678 Σ. Com. Beren.	1678	12	38	55	+15	5·4	60·3	6½,	7½	204·3 —	31·07 -
49	35 Com. Beren.	1687	12	46	54	+21	57·2	65·3	5½,	8½	52·8 +	1·31 + ?
50	42 Com. Beren.	1728	13	3	40	+18	12·9	65·5	4½,	5	193·9 +	0·25 -
51	4530 B.A.C. Virg.	1757	13	27	39	+ 0	21·1	63·3	8,	9	59·0 +	2·00 ± ?
52	25 Can. Venat.	1768	13	31	53	+36	57·5	65·4	6,	7	round —	.. +
53	1785 Σ. Boötis	1785	13	43	16	+27	38·0	64·9	7,	7½	192·4 +	2·60 -
54	1819 Σ. Virginis	1819	14	8	48	+ 3	44·2	63·0	7½,	8	32·3 -	1·29 + ?
55	1830 Σ. Boötis	1830	14	11	33	+57	16·2	60·0	8½,	9	278·2 +	5·30 +
56	π Boötis	1864	14	34	36	+16	58·6	66·4	3½,	6	100·6 +	5·73 -
57	1876 Σ. Libræ	1876	14	39	31	− 6	50·6	63·3	8,	8	65·9 +	1·20 ± ?
58	ε Boötis	1877	14	39	18	+27	37·4	65·4	3,	7	325·5 +	2·92 +
59	ξ Boötis	1888	14	45	22	+19	38·5	65·7	3½,	6½	300·8 -	5·41 -
60	44 Boötis	1909	14	59	31	+48	9·7	63·3	5,	6	239·5 +	4·75 +
61	1 B Cor. Borealis	1932	15	12	43	+27	18·7	63·2	6,	6½	290·2 +	1·18 -
62	η Cor. Borealis	1937	15	17	50	+30	45·6	66·5	6,	6½	33·1 +	1·12 +
63	μ² Boötis	1938	15	19	36	+37	48·2	66·5	8,	8½	180·3 —	0·30 —
64	δ Serpentis	1954	15	28	36	+10	58·5	66·4	3,	5	189·8 —	3·42 +
65	γ Coronæ Borealis	1967	15	37	16	+26	42·5	66·5	4,	6½	round	..
66	51 Libræ A B	1998	15	57	13	—11	0·8	66·5	4½,	5	161·0 +	0·40 +
67	„ A C	..		..		..		65·5	4½,	7½	69·6 -	7·10 +
68	49 Serpentis	2021	16	7	14	+13	52·8	64·8	7,	7½	324·6 +	3·53 + ?
69	2026 Σ Herculis	2026	16	8	17	+ 7	42·4	65·4	8½,	9½	326·1 —	1·50 —
70	σ Coronæ Bor. A B	2032	16	9	49	+34	11·4	65·8	6,	6½	192·4 +	2·97 +
71	„ A C	..		..		..		62·6	6,	11	88·3 —	51·04 +
72	λ Ophiuchi	2055	16	24	21	+ 2	16·3	65·5	4,	6	25·2 +	1·51 +
73	ζ Herculis	2084	16	36	24	+31	50·1	66·8	3,	6	229·2 —	0·83 +
74	2106 Σ. Ophiuchi	2106	16	44	58	+ 9	37·9	63·5	6,	8	321·3 —	0·50 —
75	167 B Herculis	2107	16	46	42	+28	52·9	65·0	6½,	8½	189·3 +	0·93 —
76	*270 P. XVI. Ophiu.	2114	16	55	44	+ 8	38·5	59·3	6½,	7½	147·3 +	1·31 ± ?
77	210 B Herculis	2120	16	59	30	+28	16·1	66·4	6½,	9	272·9 —	3·56 +
78	μ Draconis	2130	17	2	39	+54	38·7	65·6	4,	4½	181·8 —	2·79 —
79	36 Ophiuchi	..	17	7	20	—26	23·9	62·4	4½,	6½	212·4 —	4·22 —
80	δ Herculis	2137	17	9	42	+24	59·7	66·7	4,	8½	179·6 +	20·18 —
81	ρ Herculis	2161	17	19	12	+37	16·1	62·3	4,	5½	309·5 +	3·61 ± ?
82	*5910 B.A.C. Ophiu.	2173	17	24	42	— 0	58·5	54·6	7,	7	150·5 —	1·37 +
83	μ¹ Herculis B C	..	17	41	23	+27	48·1	66·7	10½,	10½	85·0 +	1·10 —
84	τ Ophiuchi	2262	17	56	0	— 8	19·6	66·7	5,	6	248·0 +	1·60 +

...me of Star.	Struve's No.	R.A. 1870. h m s	Decl. 1870. ° ′	Epoch 1880+	Mag.	Position. °	Distance. ″
...hiuchi*	2272	17 58 52	+ 2 32·5	66·6	4½, 7	101·1−	5·27 −
...e	..	18 32 32	+38 39·9	65·6	1, 11	150·1+	46·15 +
... Lyræ	2382	18 40 0	+39 32·0	63·1	5, 6½	19·3−	3·04 −?
... Lyræ	2383	..	..	65·8	5, 5½	142·6−	2·35 ±?
... Serpentis	2402	18 43 30	+10 31·4	56·6	8, 8½	213·4+	0·89 +?
...VIII. Aquil. A B	2434	18 56 3	− 0 53·5	64·6	9, 9	136·8−	24·29 −
B C	..	..	..	64·6	9, 10½	69·6−	1·79 ±?
... Vulpeculæ	2455	19 1 19	+21 58·9	64·9	7½, 9½	115·5−	3·53 −
... XIX. Drac.	2509	19 15 35	+62 58·3	62·9	6½, 8	343·7−	0·80 +
...ii	2579	19 40 54	+44 48·8	66·6	3½, 9	348·3−	1·70 +?
...2. Cygni	..	20 5 40	+43 34·5	61·6	7½, 8½	316·7−	0·62 −?
... Delphini	2696	20 27 6	+ 5 0·0	56·6	8, 8½	310·2+	0·72 −
... Cygni	2708	20 33 45	+38 11·1	53·8	7, 9	340·5−	16·00 +
...ni	..	20 42 20	+36 0·8	67·0	6, 7	92·5−	0·69 ±?
...arii	2729	20 44 32	− 6 6·7	56·8	6, 7	107·8+	0·30 −
...ulei A B	2737	20 52 35	+ 3 47·9	66·7	5½, 7½	290·2±?	1·06 +
A C	..	..	..	66·7	5½, 7½	73·1−	10·55 −?
...gni	2758	21 1 4	+38 5·1	66·7	5½, 6	111·7+	18·76 +
...XXIV. Ceph.	..	21 11 4	+63 52·2	66·8	7½, 7½	244·5−	0·98 +
... Pegasi	2799	21 22 58	+10 30·6	63·0	6½, 7½	317·5−	1·44 +
...XXII. Pegasi	2877	22 8 3	+16 33·0	63·6	6½, 9½	342·2+	8·99 +
...arii	2909	22 22 7	− 0 41·1	67·0	4, 4½	336·3−	3·32 −
...2. Pegasi	2934	22 35 35	+20 45·1	63·8	7½, 9	164·7−	1·21 ±?
...hei A a	..	23 3 45	+74 41·1	65·7	5, 10	6·0+	1·15 −
...hei	3001	23 13 16	+67 24·0	62·5	6, 8½	182·1−	2·28 −?
...XXIII. Aquar.	3008	23 17 2	− 9 10·4	63·0	8, 8½	262·8−	5·59 −
...3. A C. Cassiop.	3062	23 59 24	+57 42·3	65·7	6½, 7½	269·9+	1·43 +

Part II. Suspected Binary Stars.

...ame of Star.	Struve's No.	R.A. 1870. h m s	Decl. 1870. ° ′	Epoch 1880+	Mag.	Position. °	Distance. ″
... Andromedæ	44	0 31 8	+40 16·3	65·0	8½, 9	263·2+	8·66 +
...ietis	208	1 56 16	+25 18·5	63·0	6, 8½	33·9+	1·43 −
... Cassiopeæ	234	2 7 47	+60 44·8	63·4	8, 8½	231·4−	0·70 −
...ti	295	2 34 33	− 1 14·8	64·0	6, 10	324·7−	4·63 −
... Ceti	367	3 7 18	+ 0 14·3	64·0	8, 8	257·1−	0·50 −
...onis	..	5 17 56	− 2 31·1	66·9	4, 5	86·1±?	0·95 ±?
...ionis	728	5 23 49	+ 5 50·9	63·3	5, 6½	192·2−	..
... Tauri	749	5 29 6	+26 50·5	63·0	6½, 6½	186·4−	0·60 −?
...onocerotis A B	950	6 33 49	+10 0·9	52·1	6½, 9	212·3+	3·21 +
...ncis	963	6 40 36	+59 35·9	63·4	6, 6	59·5+	0·70 −
...nis Majoris	997	6 50 8	−13 52·6	64·0	5, 8½	337·2−	2·76 −
... XIII. Cancri	1202	8 6 26	+11 14·5	63·1	8, 10	327·4−	2·50 +?

No.	Name of Star.	Struve's No.	R.A. 1870. h m s	Decl. 1870. ° '	Epoch 1880+	Mag.	Position. °	Distance. "
13	1216 Σ. Hydræ	1216	8 14 42	− 1 10·8	63·3	7, 7½	151·1 +	..
14	σ² Ursæ Majoris	1306	8 58 55	+ 67 39·7	63·2	6½, 9½	253·5 −	3·25 −
15	1316 Σ. Hydræ A B	1316	9 1 23	− 6 36·4	64·8	7, 11½	138·4 −	6·74 ± ?
16	116 B Hydræ	1348	9 17 37	+ 6 54·5	63·1	7½, 7½	328·1 −	1·66 +
17	*1357 Σ. Hydræ	1357	9 21 59	− 9 25·6	56·2	7, 10½	59·5 +	7·60 + ?
18	1500 Σ. Leonis	1500	10 53 15	− 2 44·4	60·3	7½, 8	315·8 −	1·15 +
19	1781 Σ. Virginis	1781	13 39 36	+ 5 46·0	65·7	7, 8	251·7 +	1·10 +
20	238 P. XIII. Virg.	1788	13 48 9	− 7 25·1	64·8	6½, 7½	67·7 +	2·36 ± ?
21	121 B Boötis	1825	14 10 34	+ 20 44·2	64·4	7, 8	178·8 −	3·89 +
22	70 P. XIV. Libræ	1837	14 17 42	− 11 4·6	65·0	7, 8½	314·1 −	1·34 −
23	1863 Σ. Boötis	1863	14 33 37	+ 52 7·4	64·3	7, 7	95·2 −	0·77 +
24	ζ Boötis	1865	14 34 56	+ 14 17·2	64·8	4½, 5	303·2 −	1·02 −
25	*260 B Boötis	1867	14 35 13	+ 31 50·8	49·4	8, 8½	18·5 −	1·33 −
26	1883 Σ. Boötis	1883	14 42 24	+ 6 30·5	63·3	7, 7½	262·7 −	0·80 −
27	1934 Σ. Boötis	1934	15 12 45	+ 44 15·7	64·8	8, 8½	38·1 −	6·05 +
28	1957 Σ. Serpentis	1957	15 29 46	+ 13 21·0	63·5	8, 9	155·7 −	1·53 +
29	21 Ophiuchi	..	16 45 19	+ 1 25·8	65·6	6½, 8	167·6 −	1·33 ± ?
30	3107 Σ. Ophiuchi	3107	16 51 34	+ 4 7·0	64·5	8, 8½	104·3 −	1·32 −
31	α Scorpii A a	..	16 21 26	− 26 8·5	66·0	1, 8	272·9 −	2·92 − ?
32	281 B Herculis	2165	17 21 11	+ 29 34·5	64·6	7½, 8½	51·2 +	7·10 +
33	2199 Σ. Draconis	2199	17 36 12	+ 55 49·7	63·0	7, 7½	101·4 −	1·65 ± ?
34	μ² Herculis A B	2220	17 41 23	+ 27 48·1	66·7	4, 10½	243·9 +	31·19 +
35	*73 Ophiuchi	2281	18 3 6	+ 3 58·1	54·6	6, 7½	252·0 −	1·32 −
36	417 B Herculis	2289	18 4 21	+ 16 27·0	63·0	6½, 7½	234·3 −	1·24 ± ?
37	*2384 Σ. Draconis	2384	18 38 36	+ 66 59·1	54·8	8, 9	332·8 +	0·35 −
38	2437 Σ. Sagittæ	2437	18 56 15	+ 18 58·8	63·0	7½, 7½	71·4 −	0·80 −
39	2454 Σ. Lyræ	2454	18 59 46	+ 30 11·8	65·3	8, 9	225·9 +	1·26 +
40	22 B Cygni	2525	19 21 30	+ 27 3·1	65·2	7, 7½	240·8 −	0·60 −
41	2544 Σ. Aquilæ A B	2544	19 30 53	+ 8 1·3	64·2	7, 9½	208·9 −	1·20 +
42	2556 Σ. Vulpeculæ	2556	19 33 50	+ 21 26·3	64·9	7, 7	167·7 −	..
43	2576 Σ. Cygni	2576	19 40 40	+ 33 18·4	63·3	7½, 8¾	308·8 −	3·27 −
44	*2640 Σ. Draconis	2640	20 3 4	+ 63 31·3	41·8	7, 11	23·2 −	4·99 +
45	2744 Σ. Aquarii	2744	20 56 27	+ 1 1·3	63·2	6, 7	177·5 −	1·50 ±
46	2746 Σ. Cygni	2746	20 55 22	+ 38 33·3	63·3	8, 9	283·7 +	0·80 −
47	*2760 Σ. Cygni	2760	21 1 27	+ 33 36·7	51·9	7, 8	223·9 ± ?	10·90 −
48	50 P. XXI. Cygni	..	21 9 21	+ 40 36·9	59·7	7, 7½	126·4 −	1·02 −
49	29 B Pegasi	2804	21 26 57	+ 20 8·6	64·9	7, 8	324·5 +	2·75 −
50	*37 Pegasi	2912	22 23 24	+ 3 46·4	57·1	6, 7	117·5 +	0·74 −
51	2928 Σ. Aquarii	2928	22 32 38	− 13 17·0	63·1	8, 8½	319·3 −	4·38 −
52	219 P. XXII. Aquar. A C	2944	22 41 8	− 4 54·1	62·7	7, 8	146·6 −	50·67 −
53	2976 Σ. Piscium B C	2976	23 1 26	+ 5 54·2	57·4	9½, 10	183·2 +	16·31 +
54	3046 Σ. Ceti	3046	23 50 0	− 10 12·7	63·9	8, 8½	241·5 +	2·90 +
55	37 B Andromedæ	3050	23 52 48	+ 33 0·3	64·8	6, 6½	199·5 +	3·17 −

Notes to Part I.

1. 316 B Cephei. Epoch of distance = 1857·5.
12. 257 Σ. Persei. Epoch of distance = 1857·5.

51 Libræ. Perhaps the measures of A C ought rather to be put in Part II., the reality of a change not being assured. There is some confusion in the designation of this star: Brothers at the instigation of Dawes terms it ξ Scorpii, as also did Smyth, but in retaining the appellation "51 Libræ" I have followed the better supported usage.

5910 B.A.C. Ophiuchi. Secchi gives, as measures of Position angles, W. Struve, 1830, 323°; Mädler, 1843, 166°; and himself, 1858, 325°, and hints at Mädler having made a mistake of 180°.

Dawes gives Struve as above; many by himself all about 160°, and Mädler 1854, 150°.

The true explanation would seem to be that different observers had treated, some one and some the other star as A. The magnitudes of the components being nearly or quite identical, this is not matter for much surprise.

2708 Σ. Cygni. A diminution of 20° in the angle of position in thirty years, 1823–53, is clearly established; but the change in the other element is far more marked. The distance has, in like period, increased from 9″·5 to 16″·0 an amount which is very noticeable by reason of its magnitude.

Note to Part II.

2760 Σ. Cygni. In the twenty-six years, 1825–51, the position remained absolutely identical, but the distance diminished with extreme regularity from 14·3″ to 10·9″.

On some Markings seen on Venus. By John Browning, Esq.

On the afternoon of the 14th of March I had been watching some Sun-spots with Mr. Barnes' 10½-inch silvered-glass reflector. The Sun being obscured by some trees, about 5 o'clock I set *Venus* off on the circles, and found definition better than usual. Knowing the exact direction in which to look, I now saw that the planet was visible to the naked eye. Returning to the telescope, I saw a long gradation of light from the terminator, and the extreme edge appeared unsymmetrical. Regarding the planet more attentively, I perceived a faint mottling which extended inwards from the terminator across more than one-third of the visible disk. These markings caused the planet to look something like the Moon, when it is seen faintly with a low power, in a small aperture, through a mist.

The drawing which I have now the honour to exhibit before the Society represents the appearance I have described as nearly as I have been able to portray it; but it should be viewed by oblique light, and held at some distance from the eye.

The northern horn of the planet is somewhat bulged near the termination, and then blunted just at the extremity. This I have since been able to verify.

A white spot will be noticed near the edge of the disk, opposite the terminator. This was probably caused by a cloud, such as I have often seen on *Mars;* where, when they are near the edge of the disk, they rival the ice-caps in brilliant whiteness.

On a subsequent occasion, when observing *Venus* with my own 12¼-in. silvered-glass reflector, I found the air even steadier than on the evening that I made the drawing. I had steady definition with whole aperture, and power 400; yet I could not perceive any markings on the disk. From this I conclude that the visibility of the markings depends on some peculiar condition of the planet's atmosphere.

I think I am justified in saying that *Venus* is better shown by a good reflector than by an achromatic. I do not say this only because I see it myself better; but because, at different times, I have been told by Messrs. De La Rue, Le Suer, and With, who all used reflectors, that they have made out markings on the disk of the planet, while the late lamented Mr. Dawes could never see any markings with an achromatic.

A reflector of large aperture used with a single surface reflecting eye-piece, gives, I believe, the best definition at present obtainable of this difficult object.

I propose to use such an arrangement constantly for the next few months, and trust I may be enabled to bring some more definite results before the Society.

On the Lustre of Venus. By C. H. Weston, Esq.

Sir John Herschel, in his *Outlines of Astronomy* (Art. 467), remarks that *Venus* appears occasionally in the western sky after sunset with dazzling lustre, and in favourable circumstances may be observed to cast a pretty strong shadow; and adds in a note, that such "must be thrown upon a white ground."

On the 15th inst. the sky was very clear, but subject to occasional local condensations. *Sirius*, *Orion*, and *Venus* came out with striking brilliancy; for the humid state of the atmosphere, so long as it remained transparent, necessarily produced great optical exaggeration of the heavenly bodies.

About 8 o'clock P.M. when *Venus* was in the north-westerly part of the sky, and myself and others were passing along a wall at right angles with the planet, we were struck with the shadows of all the figures projected on the wall by the vivid light which *Venus* then exhibited. I directed especial attention to the fact as one of not very usual occurrence; and the more worthy of note because the wall possessed neither whiteness nor smoothness of surface. It was built of rough stone containing much iron, which had given to it by long exposure a decidedly ferruginous brown colour, and its face was also very uneven. As the pillars of the

gateway consisted of worked Bath stone with level surfaces, I was desirous of testing more carefully the shadows thrown upon them, and here I could detect the shadow of my walking-stick, although even the worked stone was turned to a brownish white by atmospheric influence.

Of course, in the present instance, the relative position of the wall and the planet offered great advantages for the perception of shadows. Had they been at a considerable angle to each other, the delicate shadows would have been cast too far from the figures to have attracted notice, and the defining outlines of such would also have been less marked.

The wall and the gate pillars were in a clear atmosphere, on an elevation about 740 feet above the mean sea-level.

That shadows should have been cast by *Venus* in her present optical position is the more remarkable because she will not attain her greatest brilliancy (before her inferior conjunction) until 9th June.

How decided therefore (under similar favourable conditions) would these shadows have been, had they been cast by *Venus* in the greatest brilliancy of her eastern elongation upon a smooth and whitewashed wall, as suggested by Sir John Herschel.

Ensleigh Observatory, Lansdowne (above) Bath,
March 16, 1868.

Description of Zenith Telescope of U. S. Coast Survey. By G. Davidson, Esq.

(*Extracts from two Letters to Prof. Piazzi Smyth, Astronomer Royal for Scotland.*)

When I had the pleasure of visiting you in Edinburgh last June, I promised to send you a drawing of one of our improved Zenith Telescopes, for the determination of the latitude.

I had not forgotten it, but it has been impossible to have the drawing made, on account of the great pressure of business consequent upon Dr. Bache's illness.

I inclose you a drawing that is at least effective, if not very artistic, and at the same time give a short description of the instrument and methods of observing, with the formulæ for the reduction of the observed results.

The instrument was first devised by Capt. Andrew Talcott, of the U.S. Corps of Engineers, to practically carry out the principle based upon the proposition that, when the meridian zenith distances of two stars, at their upper culmination (one being north and one south of the zenith) are equal, the colatitude is the mean of their north polar distances. It is, therefore, necessary, to avoid arc readings, that the telescope, when pointed to any zenith distance, should be capable of being revolved on a vertical axis. And as two stars could rarely be found having

the same meridional zenith distance, those are selected in pairs (N. and S.), which culminate within a few minutes of time and within twenty minutes (of arc) of zenith distance of each other, and the difference of meridional zenith distance is measured by a micrometer, and changes of verticality by a delicate level.

Many improvements have been made by officers of the Coast Survey, where its value was at once appreciated; and its latest form is that proposed by the late R. H. Fauntleroy, Esq., of the Coast Survey, whereby stars in the zenith can be observed, and transit observations also made for time with the requisite accuracy.

The drawing gives a fair idea of the instrument with the latest improvements. The telescope is usually about 45 inches focal length; object-glass $3\frac{1}{4}$ inches diameter; magnifying power used about 100, by which we obtain nearly all the stars in the B.A.C.

Stops are clamped on the azimuth circle to denote when the instrument is on the meridian N. and S. The telescope is set to the nearest minute of the apparent mean zenith distance of the two stars; the star bisected at culmination by micrometer line, and micrometer and level read. Telescope revolved 180°, and second star observed in precisely the same manner. We allow five minutes between stars, and seven minutes between pairs.

All accuracy depends upon the delicacy of the level and micrometer, and these have been particularly studied, and their values very minutely determined.

Our results show that one observation (N. and S.) is as good as the average places of the B.A.C. But I cannot enter into too much detail, and will merely refer you to a very full article on the subject in Chauvenet's *Spherical and Practical Astronomy*, pp. 1350, published here in Philadelphia.

[Here follow certain formulæ for reduction, &c. extracted by the writer from his manuscript investigations and instructions.]

Germantown, Pa., U.S.A.,
Nov. 17, 1865.

About the matter of the Zenith Telescope, you are perfectly at liberty to use anything I have written or write to you about it; and I have interested myself in the matter since receiving your note, so that I hope to receive in two or three weeks an engraving of the instrument from the groundwork of what I sent you. I have written to Prof. Benjamin Peirce, Superintendent U.S.C.S., upon the subject, and he authorises me to say that if you, or any parties, desire a Zenith Telescope constructed, he will have the work upon it superintended by a Coast Survey officer, and will specially see that all the "improvements" of the instrument, as developed in field operations, are specially attended to, and adopted. I have inquired of the maker who constructs all ours, and have from him the following reply:—

Zenith Telescope of the United States Coast Survey. Prof. A. D. Bache, Supt.

Zenith Telescope of	30-inch	focal length	850	dollars.
,,	,,	36 ,,	,,	950	,,
,,	,,	45 ,,	,,	1200	,,

He has one of 51 inches focal length, which he will sell at the price for making a 45-inch. The above rates are in the U.S. legal tender currency.

After using the 45-inch telescopes for years, I am constrained to say that their weight oppresses me on mountain duty, and I prefer one of the smaller. I will obtain for you some of the results obtained by a 30-inch. In the meantime I think a 36-inch telescope would be the best under all circumstances. The overseeing of the making of the instrument by the Coast Survey would, of course, be gratuitous.

When I send you the engraving, I will try to add a copy of all the formulæ, &c., lest I overlooked anything in my former description, which was hurriedly drawn up. In latitude observations I have no hesitation in saying, after twenty-two years' practical experience in using prime vertical transits, vertical circles, and Airy's zenith sector, that the zenith telescope of the Coast Survey stands far above them. The elaborate discussion of the results obtained by all the different methods has developed the same conclusion.

In such work as I have been engaged in upon the Alaska Coast, and expect still further to carry forward, I am evolving an instrument to combine the properties of the portable transit and zenith telescope. I inclose you an engraving of the Coast Survey portable transit, with telescope of 36 inches focus. The broad idea covering my proposed instrument is to have a double horizontal frame, or one beneath that of the transit; one revolving upon the other with a short central vertical hollow axis. When to be used as a transit, the two horizontal frames are securely clamped together: when to be used as a zenith telescope, these screws are unclamped, and the instrument will revolve in azimuth, with stops on each side, to which the upper part is brought, to make the telescope play in, or very near, the plane of the meridian. This instrument will also be very useful in determining the azimuth of a mark by circum-elongation of a close polar star. This is necessary in our geographical reconnaissance of a coast where bad weather may close upon the observer when changing his transit and setting up a zenith telescope. I put my transit in the meridian generally in less than 1½ hours; observed eight or ten transits for time and instrumental corrections; then obtain ten pairs of zenith telescope stars for latitude, which usually has a probable error of less than 0″·2. The instruments are generally removed by one or two o'clock A.M., and the vessel at another station 50 or 60 miles off during the day, and ready for another set of observations at night.

Where the latitude is required for a main triangulation station, the zenith telescope observations embrace about five ob-

servations upon as many different nights (*i.e.* one observation per night) upon thirty pairs of stars. Of course this supposes that the places of the stars are well determined. We use the B.A.C. as a field basis, and after the stars are selected for work, the corrections to their B.A.C. places are used in the computations.

Germantown, Pa., U.S.A.,
February 11, 1868.

Observations of the Lunar Crater Linné.
By the Rev. T. W. Webb.

The very unfavourable weather which we have had for a long time has prevented me from turning to much account the very superior defining power of the 9¼-inch silvered speculum by Mr. With, now in my possession; but I have had a few views of the spot *Linné*, in addition to one which was made known at an early period, and the most satisfactory of these I beg permission to communicate to the Society, in the hope that they may be received as a slight addition to the evidence which is being accumulated as to the nature of this mysterious object.

1867, Nov. $17^d\ 18^h\ 30^m$. Power about 170. Definition very fine, though a little fluttering. At, or very near, *Linné*, a minute, white, not especially brilliant speck stands exactly on a dark grey terminator, quite insulated, and not surrounded by any white cloud. It is impossible to say whether it is *Linné*, but from comparison with Lohrmann I believe it to be so.

1867, Dec. $16^d\ 18^h\ 45^m$. Power 170. Air very fluttering and often clouded. Terminator through W. wall of *Maurolycus* and *Aristoteles;* a very little beyond *Bessel.*

Linné an inconspicuous object; the white cloud has become very faint, and is ill bounded; at its E. edge is a small speck of greater brightness, apparently a minute hill; but definition is too unsteady.

The preceding observations were in waning illumination, as the dates will show. In the next it was enlightened the opposite way.

1868, Jan. $1^d\ 7^h\ 30^m$. Power about 212. Air very steady, but constant clouds of varying thickness. Terminator through the pass between *Caucasus* and the *Apennines;* the E. edge of the *Mare Serenitatis* next *Apennines* is, however, still in shade.

Linné. A very hasty view seemed to show a crater of several seconds in diameter, with a shallow white interior, and a very narrow shadow on the W. side; but the cloud became too thick before it could be verified. It may have been about the size represented by Lohrmann.

The next observation was two days only before full.

1868, Jan. $7^d\ 9^h\ 30^m$. Power 170. Sharp, but fluttering, and

very frequently clouded. Terminator bisecting *Seleucus*, and half its own breadth beyond *Phocylides*.

Linné neither so large nor so bright as *Posidonius* γ. Each, but most certainly *Linné*, seems to have a minute brighter spot in the centre.

The next two were in the wane.

1868, Jan. 14^d 19^h 15^m. Power 170. Sharp and clear, but often obscured by cloud. Terminator through W. edge of *Cyrillus* and *Catharina*, and the Serpentine Ridge of *M. Serenitatis*.

Linné. A white spot, not very large or bright, with something brighter in its centre, not very readily seen. It was a little E. of the centre, and looked, as far as I could judge, like a very small white hill.

1868, Jan. 15^d 19^h 20^m. Power 110. Generally thick haze; often cloud; bad definition in a few clear intervals. Terminator about two-thirds diameter of *Autolycus* beyond *Linné*.

Linné. I was for a long time deceived by mistaking for this object *Linné* B, which was a little beyond the terminator; and it was not till I had examined the map that I perceived my error: it had then become cloudy, and had it continued so, I should have believed that nothing had been visible on the site of *Linné* except some grey mounds; but fortunately a clear interval of a few minutes enabled me to repeat the observation; when I found in the right position a very small white spot, very much smaller than the white cloud, of which there was not a trace; though distinctly defined upon the dark grey surrounding level, it was by no means a bright object. It was, I think, elongated N. and S., and had the aspect of a hill, but perhaps more from prepossession than any real evidence, for under present definition it was impossible to be certain of any shadow on the W. side. A winding grey ridge passed from S. to N. between it and the terminator, which it touched N.W. of *Linné*, and then returned in a less connected form towards E. The white hill was so far from it, that I question whether the cloudy patch, if visible, would do more than reach the foot of the ridge.

The last observation was in increasing illumination, 2^d after first quarter.

1868, Feb. 3^d 7^h 15^m. Power 212. Sharp, but unsteady definition. Terminator two-thirds across *Sinus Iridum*, of which the whole border is enlightened.

Linné is decidedly less bright than *Posidonius* γ. I sometimes fancied I saw a trace of the shadow of the W. side of a low ring, as large as that drawn in the map; but my impression was faint, and while writing subsequently I feel less certain about it than I could wish.

10^h 30^m to 11^h 15^m. Definition has become unusually beautiful, though not perfectly steady, and clouds frequently interrupt the observation. *Sinus Iridum* all enlightened, but E. part in heavy penumbra. *Linné* at best moments,—in fact usually, is very distinctly seen as a minute deep crater with black

interior shadow and bright ring: once or twice I even fancied I could see part of the bottom in bright illumination; but of this I could not be certain. It lies in the centre of the white cloud, of which it occupies $\frac{1}{3}$ or $\frac{1}{4}$. I thought it bore about the same proportion to the neighbouring crater *Linné* A, but I did not at the time make a direct comparison of the cloud and this crater. It was, I think, about the size of the minute crater *n. f.* the N. end of the *straight wall*, and could not have exceeded,—probably did not attain,—1″ in interior diameter. It was seen, but not so well, with a power of 450; the eye-piece, however, was not quite equal to the other (a microscopic doublet of admirable sharpness), and the air might have changed.

This last observation is sufficiently remarkable, from the evidence afforded by the distinct black shadow, of the extraordinary depth and steepness of the crater, above which the sun could not have been elevated much less than 50°.

Hardwick Parsonage, Feb. 8, 1868.

The Lunar Crater Linné. By Edward Crossley, Esq.

On Monday evening, March 30th, 1868, I had an excellent opportunity of viewing *Linné.* Age 6·6 days; aperture $9\frac{1}{3}$ refractor. Equatoreal by Cooke.

With low powers the shadow of the central eminence was easily seen. With 240 it was plainly resolved into a small crater, and with 470 the crater was brought out into as strong relief as any of the other craters on the *Mare Serenitatis.* It appears to be about a mile in diameter.

The obscuration round the crater is very much subdued to what it was last year, and appears circular, and somewhat dished, but badly defined at the edges.

In October 1867, the Moon waning, with the terminator on Bessel, and with the same power and aperture, I could only make out the shadow of an eminence in the centre of *Linné.*

On the Tuesday evening, March 31st, 1868, though the Moon was a day older, the central crater was quite an easy object.

Halifax, April 1st, 1868.

The Lunar Crater Linné. By Capt. Noble.

The night of Monday, the 30th of March ult., being peculiarly fine, I occupied myself from $8^h\ 20^m$ to 9^h L.M.T. in the examination of *Linnæus;* employing powers of 154 and 255 in my 4·2-inch Equatoreal for that purpose.

The detail was even better and more sharply seen than on the 3d of last November, and the outline of the wall of the crater

was exceedingly plain. The west and south-west portions of this wall cast a distinct shadow in the interior: no such shadow, however, was projected by the east wall on the surrounding *Mare*. Hence it is evident that, shallow as is the western half of the ring, the eastern is shallower still. I could see nothing of the minute crater. The Moon's age at the mean epoch of this observation was 6·56 days.

At $11^h\ 10^m$ L.M.T. I returned to my scrutiny of *Linnæus*. The shadow of the western wall had disappeared, and it was only by sustained attention that *Linnæus* could be made out as a crater at all. A cursory glance showed it as a nebulous spot. The Moon set about 20 minutes after midnight, but I am persuaded from what I saw, that very shortly afterwards nothing but the well-known hazy, ill-defined patch can have occupied the place of *Linnæus*, in every locality where the Moon was above the horizon.

Forest Lodge, Maresfield, Sussex,
8th April, 1868.

Proposal for a new Star Atlas.
By R. A. Proctor, B.A.

It appears to me that a series of star-maps fulfilling the following conditions would form a desirable addition to scientific libraries:—

The series should consist of

I. A moderate number of maps,
II. Not too large for convenient use,
III. Uniform in size and shape,
IV. On the scale of an 18-inch globe (at least),
V. With little distortion, and
VI. With little variation of scale or area,
VII. On a *central* projection or construction uniform for each map; and
VIII. Exhibiting satisfactorily the connection between the different maps of the series.

A little consideration will show that all these conditions are important, and some of them essential for charts intended to occupy a space midway between popular maps and such charts as Argelander's. Accordingly it would not suffice merely to increase the scale of any extant popular maps. The effect of such a process is seen in the large maps of the Society for the Diffusion of Useful Knowledge, which are not only too unwieldy for convenient use, but represent small star-groups with preposterous distortion. In fact, the gnomonic projection, which has valuable properties for popular maps, seems wholly unsuited for maps of a higher class. The astronomer seeking to master the configura-

tion of small star-groups, the depths within which he proposes to explore, requires more efficient aids than "straight-line pointing," which may co-exist (as every mathematician knows) with the most egregious distortion and scale-variation.

The stereographic projection is far superior to the gnomonic for such purposes as we are now considering. But there is a somewhat rapid scale-variation in this projection, which is likely to prove misleading. It will be found difficult to propose any plan for stereographic maps in which the variation of scale and area would be nearly so small as in the construction I am about to propose.

My plan is to divide the sphere into twelve spherical pentagons, the centres of which would be the angular points of a dodecahedron inscribed within the sphere. The poles of the sphere should be the centres of two of the pentagons.

It will be observed that this mode of dividing the sphere is that adopted in my gnomonic star-maps. But, instead of the gnomonic projection I propose the use of the equi-distant construction; and I suggest, also, that the small circles surrounding each spherical pentagon should be made the boundaries of the twelve maps.

The scale-variation in the above arrangement would be exceedingly small: it would clearly be represented by the ratio of the *spherical* radius to the *true* radius of the small circle bounding each map; *i.e.* by the ratio

$$\sin\ 37^\circ\ 22'\ 38''\cdot5 : \text{arc}\ \ 37^\circ\ 22'\ 38''\cdot5$$

or

$$40 : 43$$

very nearly. This ratio would also represent the variation of area.

I send with this the half of a polar and the half of an equatorial map, on the scale of an 18-inch globe, divided to every degree of arc. The equatorial map was drawn as follows: the position of the point of intersection of every fifth circle of right ascension with every fifth declination-parallel was calculated by the usual spherical formulæ, and marked down, accordingly, in the map.

Of the ten equatorial maps, only two would have their *dark* circles of R.A. in the position shown in the half-map. In all other respects the lines of R.A. and declination would be alike in the ten equatorial maps.

Maps on this scale might contain all the 8377 stars of the B.A. catalogue, and at least 2000 nebulæ. I would suggest the reduction of star-places to the year 1880 as in my star-maps. Perhaps, also, the introduction of the heliocentric orbits of the planets would make the series more useful.

The connexion of the maps would be sufficiently indicated by the overlapping segments; or, my gnomonic maps might be used as index-plates.

D

The boundaries of the constellations would have to be introduced, but I think the constellation-figures should be omitted. They would disfigure a scientific atlas. If my small maps were used as suggested, all that would be required in this way would be supplied.

The addition of duplicate maps showing the stars only on a black back-ground would, I think, be desirable.

The longitude and latitude lines would not be required, as every observer is, doubtless, familiar with the processes for reducing R.A. and declination to longitude and latitude, and *vice versâ.*

I would suggest also the addition of a short line at the intersections of every fifth meridian and parallel,— such line indicating, by its length and direction, the amount and direction of the precessional change for 100 years (say) at that point of the celestial sphere.

The labour of drawing the meridians for each map could be saved by instructing the engraver to draw the meridians and parallels of one polar and one equatorial map; and to take a sufficient number of impressions of these *on dry paper* (to avoid shrinkage). On these impressions the stars and constellation-boundaries could then be drawn in by whoever undertook the construction of the maps.

The reduction of star-places to 1880 (to the degree of accuracy required) would not take long. In my *Handbook of the Stars* there are the reduced places of 1500 stars extracted from the B. A. Catalogue. It may be noticed that the reduction is simplified when it is made for thirty years, since we have only to halve the correction in *seconds* and estimate the result as *minutes.*

The *Annals of the Astronomical Observatory of Harvard College*, published up to this date, are —

Vol. I. Part I. History and Description of the Observatory;

Vol. I. Part II. Zone Catalogue of 5500 Stars;

Vol. II. Part I. Observations of the Planet *Saturn;*

Vol. III. Account of the Great Comet of 1858;

Vol. IV. Part I. Catalogue of Polar and Clock Stars. There is now published, 1867;

Vol. II. Part II. containing the Second Series of Zone Observations, of which the first series is continued;

Vol. II. Parts II. III. and IV. are yet unpublished; and

Vol. V. entitled Observations upon the Great Nebula of *Orion* by the late G. P. Bond, Director of the Observatory of Harvard College, edited by Truman Henry Safford, Director of the Dearborn Observatory of Chicago, Introd. pp. viii. to xxvi., text pp. 1 to 189.

The observations given in the volume were commenced by Prof. G. P. Bond in the year 1857. During that winter and the

next spring they were continued so far that most of the stars between the limits of the R.A. of the catalogue contained in the work, and within 20′ of Decl. of the trapezium were already observed. Owing, however, to the apparition of Donati's Comet (and also partly to the decease of Prof. W. C. Bond in 1859), the work of reduction was discontinued, and suffered an interruption of some years. But as soon as vol. iii. was finished, Prof. G. P. Bond returned to the nebula of *Orion*, and from that time until his death in 1865, devoted much of his time and of his gradually failing strength to that object.

The work was left unfinished at the author's death, and the completion as far as possible, and publication, were left to the editor. It was, therefore, necessary for him to complete those portions which were so far advanced that the form which Prof. Bond desired to give them could be recognised, and for the remainder to give as far as possible the original observations as they stood in the records of the Observatory, with the amount of reduction necessary for astronomers to derive as much advantage as possible from them.

The charts and engraving executed by Mr. Watts under the author's personal supervision are appended to the engraving of the nebula not completed in 1864, and the edition of it printed.

A drawing by Prof. W. C. Bond, from which an engraving was made for vol. iii. new series, *Mem. American Academy*, was given to Mr. Watts to re-engrave, as the original engraving did not appear sufficiently accurate, and the differences between the two are of some importance in respect to controverted points. It was, however, found an extremely difficult task to reproduce the original drawing.

Elements of Minor Planets (94) *and* (95).

The following elements calculated by Dr. Tietjen are given *Ast. Nach.* No. 1863.

(94).		(95).	
1867, Nov. 28·0, Berlin M.T.		1868, Feb. 12·0, Berlin M.T.	
$M = 340° 30' 39''.5$	Mean Eq. 1867·0	$M = 39° 23' 39''.3$	Mean Eq. 1868·0
$\omega = 40\ 50\ 23.2$		$\omega = 144\ 33\ 46.1$	
$\Omega = 4\ 32\ 9.3$		$\Omega = 244\ 20\ 50.3$	
$i = 8\ 5\ 27.0$		$i = 12\ 52\ 6.5$	
$\phi = 5\ 10\ 18.6$		$\phi = 8\ 32\ 13.3$	
$\mu = 630''.5129$		$\mu = 659''.8598$	
$\log a = 0.500208$		$\log a = 0.487037$	

ERRATUM IN LAST NOTICE.

Page 154, *for* H. C. Key, Esq. *read* the Rev. H. Cooper Key.

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// MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. XXVIII. *May* 8, 1868. No. 7.

Admiral MANNERS, President, in the Chair.

Isaac Patchett, Esq., Birstall Academy, Leeds,
was balloted for and duly elected a Fellow of the Society.

Occultations visible in the Month of August, 1868, *at Madras, and along the Shadow Path of the Total Eclipse of the Sun in India.* By C. Ragoonatha Chary, First Assistant at the Madras Observatory.

(*Communicated by N. R. Pogson, Government Astronomer at Madras.*)

In consideration of the importance attached to the coming great Solar Eclipse of August next in the Indian Peninsula, and of the interest evinced by Her Majesty's Government and by scientific Societies to secure observations calculated to throw light upon the physical constitution of the Sun, I have taken the liberty of communicating the prediction of certain occultations which will, I trust, be deemed worthy of insertion in the *Monthly Notices* of the Society.

It may not be out of place here to mention that approximate calculations for twelve stations on the central line have been made by me, and that two maps, showing respectively the track of the Moon's shadow across India, and the positions of such stars and planets as will most probably be visible to the naked eye, have been prepared in conformity therewith. My results, together with a popular description of the usual phenomena of a total eclipse by N. R. Pogson, Esq., Government Astronomer, have

been published in the Madras Almanac of the Male Asylum Press, and seven spare copies of the same, in pamphlet form, are herewith forwarded for distribution, and review in the *R. A. S. Monthly Notices.*

As it is intended that several competent observers shall be stationed in different localities along the central line in the Indian Peninsula to secure noteworthy observations of this great phenomenon, and as it is also probable that these observers may have to remain in their places some days prior and subsequent to the date of the occurrence of the eclipse, to ascertain their geographical positions, &c., it occurred to me that, by means of corresponding observations of the occultations of stars by the Moon at the Madras Observatory, as well as at the different places in the track of the shadow at which the eclipse may have been recorded, the terrestrial longitudes of such stations might be pretty accurately determined.

In the hope that such preliminary calculations may prove useful, I have selected such stars only as can be easily observed; and these, twelve in number, will suffer occultation in the month of August, and will be equally visible at Madras and throughout the shadow line. The times of disappearance, reappearance, and the points of contact for these stars, are computed for three equidistant places on the centre line; one on the western coast near Viziadroog, another in the middle near Muktull, and the third on the eastern coast near Masulipatam. As the shadow crosses India nearly along the same parallel of latitude, the variations in time, &c., for the intermediate stations will only be affected by the difference of longitude, and such variations I have therefore given, both for disappearance and reappearance, for each occultation computed. They will enable observers to ascertain easily and approximately the times and points of contact for all intermediate stations.

The tabulated results have been obtained exclusively by the aid of the slide-rule. They are not likely to be uncertain by more than half a minute in time, or a degree in the angular points of contact.

For the Madras Observatory.

			Disappearance.			Reappearance.		
1868.	Star's Name.	Mag.	Local Mean Time.	Angle from North Point.	Angle from Vertex.	Local Mean Time.	Angle from North Point.	Angle from Vertex.
			h m	°	°	h m	°	°
Aug. 2	7043 B.A.C.	6½	13 [illegible]	112 E	58 L	15 4·8	151 W	[illegible] L
3	24 Capricorni	5	12 4·5	43 E	54 L	13 44·0	94 W	[illegible] E
4	35 Aquarii	6	[illegible]	64 E	3 E	18 4[illegible]	134 W	[illegible] L
10	α Ceti	4	11 1[illegible]·4	[illegible] E	158 L	12 [illegible]	121 W	[illegible] E
12	[illegible] B.A.C.	[illegible]	12 [illegible]	[illegible] E	134 L	13 [illegible]	112 W	[illegible] E
12	Aldebaran	1	13 [illegible]	[illegible] E	[illegible] L	14 [illegible]	[illegible] W	[illegible] E
14	[illegible] Lalande	5	14 [illegible]	[illegible] E	[illegible] L	15 [illegible]	82 W	[illegible] E
14	[illegible] Lalande	5	14 [illegible]	58 E	116 L	15 [illegible]	58 W	[illegible] L

1868.		Mag.	Disappearance. Local Mean Time.	Angle from North Point.	Angle from Vertex.	Reappearance. Local Mean Time.	Angle from North Point.	Angle from Vertex.
			h m	°	°	h m	°	°
Aug. 19	21487 Lalande	7½	7 10·3	163 E	86 L	7 41·2*	123 W	161 L
22	xiii. 1016 Weisse's Bessel	8	9 34·6	65 E	11 R	10 17·9*	35 W	113 R
23	ξ' Libræ	6	7 20·7	128 E	68 L	8 34·9	94 W	163 R
25	5579 B.A.C.	5	8 46·3	151 E	98 L	9 38·0	137 W	161 L

* Star below the horizon.

For East Longitude 73° 30′ and North Latitude 16° 35′.

1868.	Star's Name.	Mag.	Disappearance. Local Mean Time.	Angle from North Point.	Angle from Vertex.	Reappearance. Local Mean Time.	Angle from North Point.	Angle from Vertex
			h m	°	°	h m	°	°
Aug. 2	7043 B.A.C.	6½	13 9·1	86 E	49 L	14 37·9	126 W	179 L
3	29 Capricorni	5	11 30·5	28 E	48 L	12 50·2	69 W	82 R
4	38 Aquarii e^2	6	17 9·5	48 E	17 R	18 15·0	95 W	166 R
10	μ Ceti	4	10 55·0	65 E	137 L	11 52·3	106 W	31 R
12	1406 B.A.C.	7	12 16·1	63 E	134 L	13 7·8	95 W	21 R
12	Aldebaran	1	13 15·3	53 E	127 L	14 10·0	88 W	10 R
14	12599 Lalande	8	13 59·7	45 E	115 L	14 36·8	61 W	13 L
14	12650 Lalande	8	14 50·7	5 W	69 L	14 54·4	13 W	63 L
19	21487 Lalande	7½	6 36·3	154 E	79 L	7 16·8	111 W	176 L
22	xiii. 1016 Weisse's Bessel	8	9 10·3	45 E	27 R	9 39·6	13 W	87 R
23	ξ' Libræ	6	6 33·6	122 E	75 L	7 56·4	83 W	144 R
25	5579 B.A.C.	5	7 49·9	136 E	100 L	9 6·3	118 W	172 R

For East Longitude 77° 20′ and North Latitude 16° 25′.

1868.	Star's Name.	Mag.	Disappearance. Local Mean Time.	Angle from North Point.	Angle from Vertex.	Reappearance. Local Mean Time.	Angle from North Point.	Angle from Vertex.
			h m	°	°	h m	°	°
Aug. 2	7043 B.A.C.	6½	13 35·4	92 E	48 L	14 56·5	133 W	169 L
3	29 Capricorni	5	11 54·4	33 E	43 L	13 20·9	77 W	104 R
4	38 Aquarii e^2	6	17 27·2	53 E	14 R	18 31·7	99 W	171 R
10	μ Ceti	4	11 9·3	67 E	141 L	12 8·2	110 W	34 R
12	1406 B.A.C.	7	12 29·9	66 E	138 L	13 23·5	99 W	24 R
12	Aldebaran	1	13 29·7	57 E	133 L	14 28·0	93 W	14 R
14	12599 Lalande	8	14 12·2	50 E	122 L	14 54·9	67 W	8 L
14	12650 Lalande	8	14 57·6	13 E	88 L	15 18·0	31 W	46 L
19	21487 Lalande	7½	6 51·3	151 E	77 L	7 31·7	110 W	177 L
22	xiii. 1016 Weisse's Bessel	8	9 25·8	48 E	25 R	9 56·7	16 W	90 R
23	ξ' Libræ	6	6 56·9	119 E	67 L	8 17·2	83 W	147 R
25	5579 B.A.C.	5	8 15·6	136 E	93 L	9 27·1	121 W	178 R

For East Longitude 81° 10′ and North Latitude 16°. 15′.

1868.	Star's Name.	Mag.	Disappearance. Local Mean Time.	Angle from North Point.	Angle from Vertex.	Reappearance. Local Mean Time.	Angle from North Point.	Angle from Vertex.
			h m	°	°	h m	°	°
Aug. 2	7043 B.A.C.	6¼	14 0·7	100 E	51 L	15 14·0	140 W	159 L
3	29 Capricorni	5	12 18·4	39 E	39 L	13 50·3	86 W	122 R
4	38 Aquarii e^2	6	17 44·2	58 E	10 R	18 47·4	103 W	176 R
10	μ Ceti	4	11 24·0	70 E	144 L	12 24·3	113 W	37 R
12	1406 B.A.C.	7	12 43·8	69 E	142 L	13 39·5	101 W	25 R
12	Aldebaran	1	13 44·8	62 E	139 L	14 46·1	99 W	19 R
14	12599 Lalande	8	14 25·2	55 E	127 L	15 11·6	72 W	4 L
14	12650 Lalande	8	15 9·1	23 E	99 L	15 38·4	41 W	36 L
19	21487 Lalande	7½	7 6·0	148 E	74 L	7 46·6	108 W	179 L
22	xiii. 1016 Weisse's Bessel	8	9 40·8	50 E	23 R	10 13·5	20 W	94 R
23	ξ′ Libræ	6	7 20·3	118 E	61 L	8 37·6	84 W	150 R
25	5579 B.A.C.	5	8 41·8	137 E	88 L	9 47·7	125 W	176 L

Variations for one Degree of East Longitude, to obtain the times and points of contact in the neighbourhood of the three above-mentioned Geographical Positions.

1868.	Star's Name.	Mag.	For Disappearance. Time.	N.P. Angle.	Ver. Angle.	For Reappearance. Time.	N.P. Angle.	Ver. Angle.
			m	°	°	m	°	°
Aug. 2	7043 B.A.C.	6¼	+6·7	1·8 E	0·3 L	+4·7	1·8 W	2·6 R
3	29 Capricorni	5	+6·3	1·5 E	1·2 R	+7·8	2·2 W	5·2 R
4	38 Aquarii e^2	6	+4·5	1·3 E	0·9 L	+4·2	1·0 W	1·3 R
10	μ Ceti	4	+3·8	0·7 E	0·9 L	+4·2	0·9 W	0·7 R
12	1406 B.A.C.	7	+3·6	0·8 E	1·1 L	+4·1	0·8 W	0·5 R
12	Aldebaran	1	+3·9	1·3 E	1·6 L	+4·7	1·5 W	1·2 R
14	12599 Lalande	8	+3·3	1·2 E	1·6 L	+4·5	1·4 W	1·1 R
14	12650 Lalande	8	+2·4	3·6 E	3·9 L	+5·7	3·7 W	3·4 R
19	21487 Lalande	7½	+3·9	0·7 W	0·6 R	+3·9	0·3 E	0·5 L
22	xiii. 1016 Weisse's Bessel	8	+4·0	0·6 E	0·5 L	+4·4	0·9 W	0·9 R
23	ξ′ Libræ	6	+6·1	0·5 W	1·8 R	+5·4	0·1 W	0·8 R
25	5579 B.A.C.	5	+6·8	0·2 E	1·6 R	+5·4	0·8 W	1·6 R

A Catalogue of Spectra of Red Stars. By Father A. Secchi.

In a letter addressed to Admiral Manners, President of the Society, Father Secchi writes:—

"I send you, according to my last letter, a part of the Catalogue

of Red Stars, examined with the spectroscope. Its construction has been improved by using only cylindrical lenses for the eye-piece, which has been made by M. Merz, and works admirably well. You will see that there is a new type of stars (the fourth) which is described in my Memoir in the *Soc. Italiana*, plate ii. fig. 7. I have already found several of that kind, so that it deserves to be characterised as a particular type. This classification is very curious indeed. I am, however, surprised to see some zones always at the same places; so that there is a great cosmical law which is about to come forth; but, for the present, we must wait until the review of all the stars has been accomplished. You see, however, that the red stars make quite a family by themselves, which is very distinct.

"I have examined (yesterday) the spectrum of Brorsen's Comet, although it was a little hazy and low. I have found it discontinuous, with a very bright and large zone in the green, and two narrower, but bright, also in the yellow and red, and a sufficiently strong zone in the blue. I hope to be able to send a drawing of it, but I must wait for better sky.

"*Rome, April* 23, 1868."

A Catalogue of Spectra of Red Stars.

The Numbers are those of the Catalogue of M. Schejellerup, published in the *Astr. Nach.*, and in Mr. Chambers' *Astronomy*. The position is his own, without further correction. In explanation of the description, I say that 1st type is *Sirius* or *α Lyræ*; 2d type of yellow stars is *Pollux* and the Sun; the 3d type is *α Orionis*, *α Herculis*; the fourth type is *Lal.* H. C. No. 12561, described in my memoir printed in the *Soc. Italiana.* In a second communication I will give the rest, since some want verification, although they have been observed. The indication *figured* is relative to the figures (coloured) which are at the Observatory. I have used the word *column* to indicate the large divisions in shape of pillars, which is characteristic to the third type in *α Herculis*, &c.

No. of Schej.	R.A. h m	Decl. ° ′	Mag.	Description and Colour (Sp. = Spectrum.)
11	1 20·6	−33 17	6	Rose; sp. discontinuous, with zones.
12	1 23·4	+ 2 9	v. 8	Pale red; nothing particular.
16	1 59·0	+ 0 46	var.	Red; very weak.
17	2 8·1	+24 24	var.	Very rich yellow in the spectrum.
19 α Ceti	2 12·3	− 3 37	var.	In the max. of 3d mag. This star now has a sp. like α Orionis and β Pegasi, but with sharper lines, and resolved in more black field. Very fine object.
Algol	2 59·8	+40 27	v. 4	Type of α Lyræ even in the minimum.

No. of Schej.	R.A. h m	Decl. ° ′	Mag.	Description and Colour (Sp. = Spectrum.)
23	2 34·8	+31 50	neb.	Weak sp. with zones.
26	3 9·4	− 6 14	7	Yellow; sp. continuous.
33	4 13·7	−6 3	7·7	Sp. cont.; near it is another ✱ with zones.
34	4 14·2	+20 29	6	Pale red; sp. striated, but without zones.
36	4 20·6	+ 9 51	7½	Yellow orange; sp. with light zones.
38	4 26·7	−11 5	6.7	Yellow red; sp. striated, without zones.
39 Tauri	4 27·9	+16 13	1	Very red colour, and its spectrum shows not only lines, but even traces of zone, and columns. It was not so last year when the star was not so red. In the green are the four characteristic lines of α Orionis.
41	4 36·7	+67 55	6½	A superb object; a spectrum of the 4th type, divided in three columns, yellow, green, blue; figured.
43	4 42·7	+28 17	8	Pale red; sp. with 3 zones, as the preceding one; 4th type.
44	4 44·6	+14 1	5	Magnificent object; it is completely resolvable in columns and lines, like α Orionis.
45	4 46·5	+ 2 15	5½	Pale rose; lines very distinct, without columns.
46	4 48·2	+ 7 33	7	Pale; lines of the 3d type.
48	4 51·4	7 55	var.	Yellow golden; uniform sp.
49	4 53?	−15 1	var.	Spectrum uniform.
50	4 54·6	+ 0 31	6	Spectrum uniform.
51	4 58·2	+ 0 59	6½	Vivid red; sp. made of three bundles of zones; red and yellow very vivid; green very large; violet; figured.
54	5 10·4	+39 11	7	Weak, with lines; feeble.
58	5 22·6	− 1 12	5	Gold yellow, deep; strong magnesium line; spectrum almost uniform in the rest; type of the yellow stars.
59	5 24·1	+18 29	5½	Magnificent object, exactly like α Orionis; completely resolvable into lines; it is α Orionis in miniature; orange red.
60	5 29·3	10 57	7½	Spectrum with bands in the green.
63	5 35	+ 2 18	7·7	Small; nothing particular.
66 α Orionis	5 47·6	+ 7 23	1 var.	This star is more red this year than the last; the spectrum is divided into columns, but the striæ do not correspond in the red with the shades of the columns. The lines of the hydrogen are very visible. In the green the lines are very distinct. A new figure made, which agrees with that of the preceding years.
67	5 49·6	+45 55	5	Gold yellow; very fine star; the spectrum is completely resolvable, like *o* Ceti; splendid object.

No. of Schej.	R.A.	Decl.	Mag.	Description and Colour (Sp. = Spectrum.)
	h m	° ′		
78	6 26·9	+38 33	6½	Star described in the *Mem. della Soc. Italiana*. This makes the 4th type, which consists in 3 large coloured zones of double extent of those of the 3d type. Magnesium very strong; vivid yellow, green, and blue; very curious thing!
83	6 49·9	70 56	6	Yellow; sp. uniform.
85	6 56·2	−27 44	3½	Yellow type; very fine striæ, with magnificent red, and strong black line in the green (magnesium).
87	6 58·9	22 55	var.	Small; nothing interesting.
89	7 1·5	−11 43	7½	Spectrum of the 4th type, but the middle black zone is narrower.
90	7 6·5	+59 10	7	Yellow; nothing particular.
91	7 7·2	+22 12	7·3	*Rufa;* weak; nothing singular.
96	7 34·6	+29 33	5	Yellow; sp. fine lines.
107	8 18·1	−37 50	6	Too low; nothing particular.
117	8 48·7	+20 23	var.	Small; nothing particular.
119	9 1·9	−25 17	4½	Gold yellow; strong line *b*, and vestiges of zones.
120	9 2·2	+31 32	6	Perfectly of the type of α Orionis, but in the interval of the columns the spaces are perfectly black, so that it gave a most discontinuous spectrum; very curious. In the green it is resolvable.
123	9 40·1	+12 5	var.	Small; sp. discontinuous, but very difficult.
Nobis.	9 16·7	−21 42	6½	Very fine yellow type of α Orionis; very neat, although small.
124	9 44·6	−22 22	6½	Type 4th, but the blue is very weak, so that there remain only the yellow, the red, and the green, separated by a very black interval.
127	10 4·0	− 7 44	6	Orange red; vestiges of weak zones. It is preceded by one of the 1st type.
128	10 5·8	−34 38	7	With very large zones and very neat; one very large in the green; it seems of the 4th type.
132	10 30 7	−12 39		Of the 4th type, very neat and luminous; it has two bright zones in the yellow, a very fine green and weak blue, separated by intervals. Figured. Colour, orange yellow.
136	10 44·8	−20 30	6½	4th type of spectrum, but reduced to the yellow and green; the rest is too weak.
137	10 52·6	−15 36	6	Clear red; type of α Orionis; well striated, but weak zones.
138	10 53·7	−17 34	8	Small, and nothing interesting.
141	11 10·9	33 52	4½	Gold yellow; the spectrum is like Capella, with fine lines; the lines F and *b* are very neat.

No. of Schej.	R.A. h m	Decl. ° ′	Mag.	Description and Colour (Sp. = Spectrum.)
152	12 38·5	+46 13	5½	A most beautiful object; the spectrum is exactly of the fourth type. The luminous zones are exceedingly vivid, and make a curious contrast with the black interruptions. There are some very strong vivid zones in the yellow and in the blue. Figured. Very singular, indeed. The colour is a vivid ruby red.

On the Variability of η Argûs and Surrounding Nebula. By F. Abbott, Esq.

The communications on the variability of η *Argûs* and the surrounding Nebula, which I had the honour of submitting to the Society, have led to the expectation of some continued observations on the light and character of both these objects.

The singularity of the nebulous portion of this region has but recently been made a subject for systematic examination, and but for the observations and beautiful monograph of Sir John Herschel, the peculiarities attached to it might have remained unknown for a long time to come.

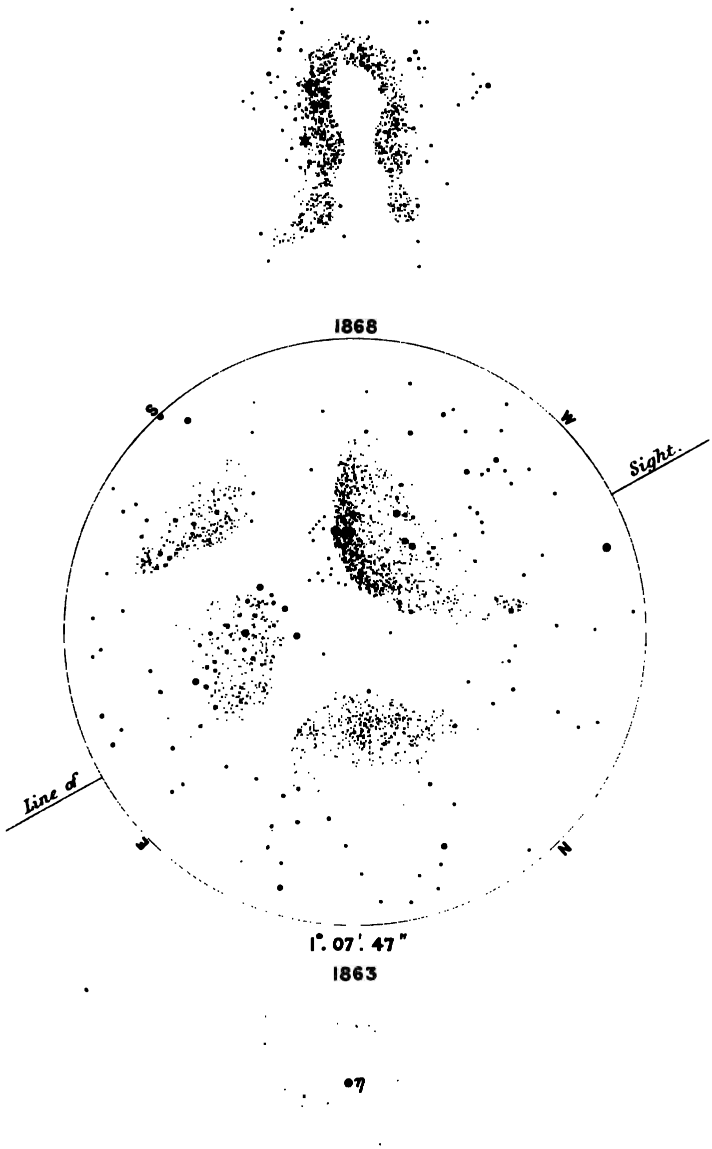
In 1677 the star η was recorded by Halley as of the 4th magnitude. Its maximum was first noted by Burchell in 1827, it being then of the 1st magnitude; and on the 30th March, 1863, it was found for the first time reduced to the 6th magnitude. Independent, however, of the variability of the star itself, there is a much more singular property belonging to the surrounding Nebula, the particular features of which I now purpose to describe.

The mutability of the Nebula will be best made apparent by the accompanying drawing (see Plate), which will at once show the different forms of the dark space, and the relative position of η *Argûs* to it, from 1834–7 to 1868.

It must not be considered, however, that the position and character here given are the only ones in which the object has appeared; a system of photographs only would be the means of assisting materially the recognition of a principle of irregularity pervading the whole structure.

The missing portion of the nebulous matter, as compared with the Cape monograph, may be thought by some to be owing to the want of a larger optical power, but when the same instruments have been used throughout, this objection as to variability must fail to have any weight. The principal instrument used is a 5-feet Equatoreal by Dallmeyer. The building being situated in a garden, the view of a small portion of the circumpolar stars is intercepted by fruit-trees: to make good this want, a 5-feet portable refractor by Varley is used in the open air, so that the

η ARGUS AS SITUATED TO THE DARK SPACE,
VARIABILITY OF THE SURROUNDING NEBULÆ,
WITH THE MAGNITUDE AND POSITION OF ACCOMPANYING STARS.
1834-7.



FROM THE YEAR 1834 TO FEBRUARY 13TH, 1868.
TAKEN AT INTERVALS.

object has been watched and noted throughout its entire revolutions round the Pole.

The eye-pieces in general use, and found most suitable for this purpose, are a Comet one of 28, an Orthoscopic of 45, and an Annular Micrometer of about the same power. A more powerful instrument would, no doubt, at any one observation, alter the apparent features of the Nebula, and render manifest changes of a somewhat different character to those here described. To witness these effects I wait the arrival of the Melbourne telescope, when I hope to have the opportunity of more correctly verifying these statements.

The investigation of the fluctuations connected with the object η *Argûs* appears not to require such refined and delicate observations as were bestowed on Herschel's sub-nebulous region near the trapezone in *Orion*, by the late Professor Bond and Earl of Rosse; nor are such powerful instruments necessary.

Take, for instance, the position of the star η, as given by Sir J. Herschel at the Cape of Good Hope, and note its position again when in the darker space, as confirmed by E. B. Powell, Esq., at Madras, and now for the third time compare its situation, removed from the dark space altogether to quite a different portion of the Nebula, and it will appear clear that the optical means employed have been ample, notwithstanding Mr. Powell was at first inclined to think that the fluctuations were only apparent, and owing to the inferiority of his instrument.

The beautiful, soft, white light given out by the nebulous matter about η *Argûs* appears to be produced, either from the increased magnitude of the stars, or the displacement of some of the nebulous mass, or probably from both, for in the former case it is difficult to say (only from its position) which is η *Argûs*, and which is not, there being so great a similarity in its size and that of some of the accompanying stars. On a clear, fine night, the object gives out fully twice as much light as that of the Great Nebula—Nebicula Major, and about three times as much as Nebicula Minor, irrespective of size. In the twilight it appears as soon as a star of the second or third magnitude, the light being white and more diffuse, very like a small white woolly cloud on a blue sky, seen in Sunlight.

At present there appears to be no further diminution in the magnitude of the star below the 6th. Being in Melbourne on the night of the 25th March, 1865, which was a very fine one, and happening to look towards η *Argûs*, I fancied that the star appeared as a distinct point in the Nebula. I immediately proceeded to the Observatory, Mr. Ellery, with his accustomed kindness, allowing me to take possession of the Equatoreal; and on examining the object, found the colour of the small accompanying stars to be the same as before described, and, with the comparative eye-piece, considered the star to be 5·5. It was about this time that Mr. Tebbutt, of New South Wales, forwarded the result of his observations to the Society, giving the star as

5·5. This appearance, however, must be considered only transitory, for many times since that period the star has not reached more than the 6th magnitude, and may be so estimated at present.

The accompanying drawing was made with an inverting eyepiece, and taken 75° East of the Meridian, to prevent the unpleasantness of taking it near the zenith. If, therefore, the line of sight is brought to correspond with the South of the Cape Monograph, the position of both drawings will be made approximately to agree at the time they were taken.

Private Observatory, Hobart Town, Tasmania,
February 29, 1868.

Questions relative to the Original Inventor of the Achromatic Telescope. By A. D. Wackerbarth, Director of the Observatory of Upsala.

The invention of the Achromatic Telescope is one of such immense importance, that all facts and all persons in any way connected with its history assume a character of the most lively interest to those engaged in the cultivation of physical or astronomical science; one naturally desires to know as much as possible about them. Now we find in Grant's *History of Physical Astronomy*, p. 353, and in Hutton's *Mathematical Dictionary* (edit. 1796), vol. i. p. 26, as also in Barlow's *Optics* (*Encyclop. Metrop.* vol. iii. p. 408), that the man who really first invented this beautiful instrument was Chester More Hall, Esq., of More Hall, in the county of Essex, who not only discovered the secret of achromatism, but even constructed several achromatic telescopes as early as 1733. The two first of these writers quote, as the source of their information, the *Gentleman's Magazine* for 1790, part ii. p. 890. Sir John Herschel, in his noble essay on "Light" (*Encyclop. Metrop.* vol. iv. p. 411), calls Mr. Hall "a gentleman of Worcestershire," not Essex. I have in vain searched a map of Essex for this gentleman's residence, More Hall, and I have also searched the descriptions, both of Essex and Worcestershire, in the *Beauties of England and Wales*, as the collectors for that voluminous work generally give some biographical account of the worthies connected with the places they describe; but I have searched in vain, as I do not find that they mention any such place as More Hall in either of the above-named counties. The *Gentleman's Magazine* is not accessible to me here (at Upsala). One circumstance that renders Mr. Hall and his telescopes especially interesting is that, according to both Hutton's and Grant's citations from the *Gentleman's Magazine*, Mr. Hall, "about 1733, completed several achromatic telescopes (though he did not give them this name) *that bore an aperture of more than $2\frac{1}{2}$ inches, though the focal length did not exceed 20*

inches, one of which is now [*i.e.* 1790] in the possession of the Rev. Mr. Smith, of Charlotte Street, Rathbone Place." It appears, then, that Mr. Hall's lenses must have been of a very good quality, for the length of his telescopes was only eight times their aperture, whereas an instrument by Dollond, preserved in this Observatory, with an aperture of four inches, has a length of ten feet, or thirty times the aperture; and even on the scale of Steinheil's telescopes (probably the most perfect yet constructed) an aperture of $2\frac{1}{2}$ inches ordinarily requires a focal length of thirty inches, or twelve times the aperture, that is, half as much again as Mr. Hall's. The length of instruments, even of the Herschel-Gauss construction, executed by Steinheil, is said to be ten times the aperture.

Mr. Hall's custom was, to have his lenses ground by ordinary workmen, but he himself put the finishing hand to the work, bringing up the surfaces to the exact curvature requisite "to correct not only the different refrangibility of rays, but also the aberration arising from the spherical figure of the lenses," so that both chromatic and spherical aberration were eliminated. It seems almost unaccountable that an invention so brilliant and so ably carried out should have fallen, and that in so short a time as thirty years, into oblivion, especially as Mr. Hall does not appear to have made any secret of it. For "old Mr. Bass, who at that time lived in Bridewell precinct, was one of those working opticians [namely, who ground lenses for Mr. Hall], from whom Mr. Hall's invention was obtained." As the invention was obtained (it is not said by whom) from Mr. Bass, it is clear that Mr. Hall must have communicated it to Mr. Bass, and he probably thought that this would be sufficient to perpetuate it, for, as he "was a gentleman of property, who did not look for any pecuniary advantages from his discovery," he no doubt supposed that, in communicating it to an artificer and tradesman, he had done sufficient to insure for ever to the public the benefit of it; but unfortunately, for his own fame, he made no legal publication of it. Who the persons were who opposed Dollond's claim to a patent, I know not, though no doubt the minutes of the trial in Westminster Hall before Lord Mansfield would inform us; but, as they produced on that occasion one of Mr. Hall's instruments as evidence of the art being already known, I take for granted that they were tradesmen, opticians, who had received the knowledge of Mr. Hall's invention from Mr. Bass. Hutton's citation from the *Gentleman's Magazine* concluded thus: "That Mr. Ayscough, optician on Ludgate Hill, was in possession of one of Mr. Hall's achromatic telescopes in 1754, is a fact, which at this time [1790] will not be disputed." This, I take it, was the instrument which Mr. Barlow says was on sale that year. But both Sir John Herschel and Mr. Barlow state (*locis citatis*) that, when they wrote, *i.e.* A.D. 1827, some of Mr. Hall's telescopes were still in existence. I conceive it therefore to be highly probable that some of them are even now to be found, and if so, it would

be in the highest degree interesting if any one having access to one of them would give an accurate and detailed description of it. Mr. Hall was evidently a man of no ordinary capacity and perseverance, and all that can be learned about him would doubtless be instructive and interesting. It would be desirable to know what sort of lenses he used, of what kind of glass, how they were disposed, and whether their number was two or more, what sort of eye-pieces the instrument was furnished with, &c., &c. Such information cannot be too highly prized.

Uppsala, April 16, 1868.

(*From the " Gentleman's Magazine,"* 1790, part ii. p. 890.)

"The writer of an Introduction to some Letters lately published, on the Improvement of Ship-building, seems to have been misled in saying, 'that great discovery in optics, the achromatic glasses, was entirely owing to three or four ingenious men assembling at a public-house in Spitalfields, to amuse themselves in friendly conversation upon mathematical and mechanical subjects.'

"As the invention has been claimed by M. Euler, M. Klingenstierna, and some other foreigners, we ought, for the honour of England, to assert our right, and give the merit of the discovery to whom it is due; and therefore, without further preface, I shall inform the author of the above quotation that the inventor was Chester More Hall, Esq., of More Hall, in Essex, who, about 1729, as appears by his papers, considering the different humours of the eye, imagined they were placed so as to correct the different refrangibility of light. He then conceived that if he could find substances having such properties as he supposed these humours might possess, he should be enabled to construct an object-glass that would show objects colourless. After many experiments he had the good fortune to find these properties in two different sorts of glass; and by forming lenses made with such glass, and making them disperse the rays of light in contrary directions, he succeeded. About 1733 he completed several achromatic object-glasses (though he did not give them this name) that bore an aperture of more than 2½ inches, though the focal length did not exceed 20 inches; one of which is now in the possession of the Rev. Mr. Smith, of Charlotte Street, Rathbone Place. This glass has been examined by several gentlemen of eminence and scientific abilities, and found to possess the properties of the present achromatic glasses.

"Mr. Hall used to employ the working opticians to grind his lenses: at the same time he furnished them with the radii of the surface, not only to correct the different refrangibility of rays, but also the aberration arising from the spherical figures of lenses. Old Mr. Bass, who at that time lived in Bridewell precinct, was

one of those working opticians, from whom Mr. Hall's invention seems to have been obtained.

"In the trial at Westminster Hall about the patent for making achromatic telescopes, Mr. Hall was allowed to be the inventor; but Lord Mansfield observed, that 'it was not the person who locked up his invention in his *scrutoire* that ought to profit by a patent for such invention, but he who brought it forth for the benefit of the public.' This, perhaps, might be said with some degree of justice, as Mr. Hall was a gentleman of property, and did not look to any pecuniary advantage from his discovery; and, consequently, it is very probable that he might not have an intention to make it generally known at that time.

"That Mr. Ayscough, optician on Ludgate Hill, was in possession of one of Mr. Hall's achromatic telescopes in 1754, is a fact which at this time will not be disputed.

"VERITAS."

Remarks on the Name of the Star ξ Scorpii (= Fl. 51 *Libræ*). By A. Brothers, Esq.

In a note to the reprint of my list of Binary Stars, which appeared in the last Number of the Society's proceedings, Mr. Chambers calls attention to the fact that I, at the suggestion of the late Rev. W. R. Dawes, had designated the star 51 *Libræ* "ξ *Scorpii*," as also did Smyth, "but in retaining the appellation "51 *Libræ*" he (Mr. Chambers) "had followed the better supported usage."

The reason for the proposed alteration will be found in the following quotation from a letter received from Mr. Dawes in Sept. 1866, in which he says, "I should really be glad if you would assist in restoring this star to *Scorpio*, from which it was taken by a mere blunder of Flamsteed's, as is generally acknowledged. Why then do not astronomers generally follow the course of that most accurate of all star-catalogue and star-map authors, Argelander, and erase this star from *Libra* (which has already *three other* ξ's, and restore it to *Scorpio*, which, without this, has no ξ at all? The best way, perhaps, to write the name would be 'ξ *Scorpii* (= Fl. 51 *Libræ*).' To continue perpetuating Flamsteed's acknowledged blunder seems to me nothing less than absurd." This, to me, was quite sufficient to authorise the change suggested, and I had no hesitation in following the advice of one so thoroughly competent to give it. Mr. Dawes named the star in his own Catalogue in the same manner.

A copy of the list of binaries, as it is printed in Mr. Chambers' book, was forwarded to Mr. Dawes, who on the 21st March, 1867, wrote to me as follows:—"I confess that I cannot help feeling much annoyed that this excellent opportunity of giving your support to the rectification of the blunder about ξ *Scorpii*

should have been thrown away; or rather, in fact, that, *contrary to your own conviction*, you should have been made to appear a *supporter of the blunder*." The words in italics are so marked by Mr. Dawes.

It will be seen by reference to the Catalogue as published by the Manchester Literary and Philosophical Society, and also in the *Astronomical Register*, that the star is named as Mr. Dawes proposed, and it will, I think, be admitted that the opinion expressed by Mr. Dawes ought to have been respected, unless any good reason could be found for the alteration made by Mr. Chambers.

The reason assigned by Mr. Chambers for publishing a second edition of my list (which is not the *Catalogue*), with the addition of a few objects of the doubtful class, is, that the R.A.'s and Decs. are not brought down to any uniform epoch. The difference of ten years, more or less, appeared to me of no consequence, as the stars could be found just as well whether the places were given for 1860 or 1870; and the places of the whole of the objects excepting those taken from Smyth's *Cycle*, are given for 1860, but the remainder I reduced to 1865; in the latter case the reduction was a matter of necessity, but in the former it was not.

Mr. Chambers remarks, "As there were other defects in it (the list), which it is not worth while to particularise," and refers to his re-computation and re-writing the list as a matter of necessity, owing to the errors he had detected in it. I shall be obliged if Mr. Chambers will point out these errors; for beyond one or two printer's errors I am not aware of the existence of any. If the Catalogue, as published in full, is the one referred to, I know of only one error, and that is the substitution of the name of one observer for another, a matter of very trivial consequence.

In the compilation of a work of this kind very much must depend on the judgment of the compiler. It may be thought by some that γ *Andromedæ* (not γ^2) and one or two other objects ought to have been omitted, but it will be seen by reference to the introduction to the Catalogue, that I have given reasons for inserting them.

On this subject Mr. Dawes wrote to me 13th Oct. 1867: "As to the way in which you have accomplished your rather arduous task, so entirely self-imposed, I assure you that I think you have done it in excellent style, and provided a very useful companion to the observatory for all double-star observers."

As to the *necessity* for such alterations as are introduced by Mr. Chambers, it will be seen by reference to my Catalogue that some of Mr. Dawes's measures are given as late as Dec. 1866 (1866·99), with many others by different observers in the same year; and I am not aware that any information to which Mr. Chambers could refer has been published since the date named, and which could justify him in altering the figures in the list which I prepared for his book.

To quote again from one of Mr. Dawes' letters, in which he says: "It is not by any means easy in some cases to determine, with anything like certainty, what are truly *binary* stars." If Mr. Chambers will go through all the published results and produce a Catalogue differing in any important particulars from the one I have already published, I have no doubt it will be found useful; at the same time I do not think much fresh material to work upon will be found, considering that a large proportion of the most valuable part of my Catalogue was supplied by the observers specially for my work.

Remarks on the Stellar Longitudes assigned by Ptolemy. By W. W. Drayson, Capt. and Major Royal Artillery, Prof. of Surveying, &c. R. M. Academy, Woolwich.

The Star Catalogue of Ptolemy being the earliest of which we have any record, has always possessed great interest to astronomers. It has been most ably arranged by the late Mr. Bailey in vol. xiii. of the *Memoirs*.

An examination of the longitudes of various stars in Ptolemy's Catalogue has revealed a singular fact, which we will express in the words of Mr. Baily. "That Ptolemy was an observer, is I think manifest from his recorded observations of the planets, as well as from other evidence which his incomparable treatise affords. Nevertheless it must be admitted that the positions of the stars in his Catalogue will not agree with the precise epoch that he has stated, but that the longitudes must be increased at least 1°, the latitudes remaining the same." The fact of the longitude being in almost every case 1° too little in the above Catalogue is so well known, that no further reference need be made to this portion of the subject.

In the *Nautical Almanac* for 1822, the longitudes of nine stars are given. By comparing these longitudes with that assigned by Ptolemy we find the following differences in degrees and minutes:—

	°	′
α Arietis	24	24
Aldebaran	24	32
Pollux	23	59
Regulus	24	45
Spica Virginis	24	35
Antares	25	30
α Aquilæ	25	19
Fomalhaut	24	15
α Pegasi	24	14

The Catalogue of Ptolemy is reduced to the first year of the

reign of Antoninus, which corresponds to A.D. 138. Hence the interval between 138 and 1815 is 1677 years.

Taking the precession in longitude to be $50''\cdot2$ annually, we ought to find for 1677 years a difference of only about $23^\circ\ 23'$ in the longitudes, instead of nearly $24\frac{1}{2}^\circ$.

The conclusion that appears to have been very generally arrived at is, that Ptolemy did not observe, but merely copied from his predecessors; this conclusion the Author thinks is not sound.

As far as the Author is aware, no satisfactory explanation has hitherto been given of the reason for all Ptolemy's longitudes being too little, thus whilst we cannot but admire the ingenuity of this ancient astronomer's method for determining longitudes, we yet perceive his results erroneous and in one direction.

The instruments used by Ptolemy and his contemporaries seem to have been of three kinds; only one of which will be referred to, viz. the Astrolabe, for taking the distances in longitude between the Sun and Moon, and the Moon and a star.

This instrument consisted of two rings fixed at right angles to each other, one in the plane of the ecliptic, the other in that of the solstitial colure. Two other rings were fixed to the instrument so as to form circles of celestial longitude, and turned about an axis, therefore coincident with the poles of the ecliptic.

When an observation was made for longitude, one of the moveable circles was directed to the Sun or Moon, having been first fixed to that degree of the ecliptic circle which expressed the known longitude of the Sun, thus the zero of the graduations was made to agree with the vernal equinox in the heavens.

Then the other moveable circle of longitude was directed to the second body, and the arc of the ecliptic between the zero and moveable circle gave the star's longitude. Considering that Ptolemy had no clocks, we think no more ingenious method than this could be adopted for determining longitudes of stars.

Having now considered the instrument in use, we will next speak of the method which must have been adopted.

In the first place, during *the evening* and earlier portions of the night was the most suitable time for using this instrument, and not after sunrise or during daylight, because the stars were not then visible. This fact being established it would follow that the order of the observations must have been made very much in the following manner:—

The Sun's longitude having been calculated for the day and hour of observation, the first movable circle was directed towards the Sun when near sunset, and thus the zero of longitudes would be fixed. A star not being visible as long as the Sun was above the horizon, the Moon would necessarily be made use of, and her longitude could readily be obtained by measuring the arc on the ecliptic between the Moon and the Sun. Hence the most suitable time for using the astrolabe would be during the first quarter of the Moon.

In the same manner that we determined the Moon's longitude by this instrument, so could we determine the longitude of a star. For by keeping one circle fixed on the Moon, whose motion in longitude was very fairly known by Ptolemy, the other circle being directed to the star, the *differenoe* in these two bodies' longitudes would be obtained, and hence the longitude of the star could be fixed.

We can now take a simple example of this method.

Suppose the Sun at the instant of observation or of fixing the instrument, to be at the vernal equinox, the Moon on the ecliptic and in quadrature. Hence the Moon's longitude would be 90°, and the angular distance between the Sun and Moon 90° on the sphere. The Moon would be on the meridian at 6 P.M., and would set at midnight. Suppose a star on the ecliptic and 90° from the Moon, this star's longitude would have been obtained by Ptolemy by obtaining its distance from the Moon at any convenient time of night, and finding the arc on the ecliptic marked by his two circles. Having fixed the longitude of any star, this star could be made use of instead of the Sun for obtaining the position in the heavens of the vernal equinox. Thus it is evident that the first start must be best made from fixing the instrument to obtain the zero of longitudes by *the Sun*. Next obtain the Moon's longitude from the Sun and then that of a star.

The Moon might be made use of for fixing the zero of longitudes, but from the irregularities of her movements, it is probable that the Sun was most generally used.

In either case, however, a very considerable error in all longitudes would arise in consequence of Ptolemy not being aware of one item used in Astronomy.

Taking the latitude of Alexandria (where it is supposed Ptolemy made his observations), to be 31°, the Moon when having its greatest north declination, would be only about $2\frac{1}{2}°$ from the zenith. Referring to the example already given, the Moon would then have been within $2\frac{1}{2}°$ of the zenith and the Sun on the horizon. Ptolemy was unacquainted with the effect of refraction, and therefore would assign to the Moon at such a time a longitude or distance from the Sun too little by the amount of the Sun's refraction, which near the horizon would be 30′. The effect of refraction would be to bring the Moon and Sun *nearer* together, for the Moon being near the zenith, the Sun would be brought nearer thereto by refraction, and hence the Moon's assigned longitude would be less than it ought to be by 30′.

If after the Moon's longitude had been thus determined by the astrolabe, a star near the eastern horizon were selected, or if Ptolemy waited until a star reached his meridian whilst the Moon had approached the western horizon, another error of nearly 30′, and in the same direction, would be added to the first, and thus from refraction alone, the star would be given 1° too little longitude.

Although the method here dealt with is that probably used

by Ptolemy, it may be supposed an extreme case, and one giving the greatest amount of error; it is so, but it may be borne in mind that in nearly every case refraction brings celestial bodies nearer together, and *never* causes them to appear further apart than they really are. In fact, when the Sun was on the horizon and the Moon at the zenith, their distance would be lessened by 34′, whilst if the Moon were on the horizon and a star at the zenith, their angular distance would be lessened by an additional 34′, making a total of 1° 8′ error in longitude of the star, which 1° 8′ would be too little. Hence a star whose true longitude was 180° would be assigned only 178° 52′.

It seems probable that Ptolemy would select the period of either the vernal or autumnal equinox as the period for determining the longitude of some star, also that he would, to ensure the Moon's longitude being as slightly changed as possible, select the time when the Sun was near the horizon, and thus these conditions, being those best adapted for the working of his astrolabe, would yet give the greatest error from refraction.

To account for all the errors in the Catalogue of Ptolemy is of course impossible, many of these are undoubtedly due to errors of observation and to imperfect instruments. The Author merely endeavours to point out in this paper how it is possible, if not probable, that with such an instrument as the astrolabe an observer unacquainted with refraction would be in error about 1° in all his longitudes, and that this 1° would be shown by omitting that amount from his assigned longitudes, which would therefore in every case be too little, as is the case in Ptolemy's Catalogue.

On a New Driving-Clock for Equatoreals.

By Thos. Cooke, Esq.

One of the great essentials of modern astronomical observation — second only in importance to the perfection of the object-glass or mirror employed—is a perfectly steady, firm, and uniform motion of the instrument under the varying resisting forces to which it is subjected.

By such a motion the fixed micrometer-wire and the (apparently) moving celestial body remain at absolute rest with regard to each other for a large interval of time.

One of the most satisfactory attempts to attain this end was made by the great Fraunhofer in the driving-clock attached to the refractor at Poulkowa. In this arrangement the motion was regulated by the friction of centrifugal balls against the interior of a conical box, the rate of motion being determined by raising or depressing the pivot of the conical pendulum; each change in the position of the pivot changing the degree of friction.

In a modified form this system has for many years been adopted in this country, but I have never been thoroughly satisfied as to its perfect uniformity: indeed, it is very difficult to imagine that a perfectly uniform rotatory motion can ever be attained by such a regulator, whenever changing resistances have to be overcome.

It was, doubtless, this consideration which induced the lamented Professor Bond to adopt his "Spring Governor," in which the regulator took the form of an oscillating pendulum, the intermittent movement being transferred into a uniform one—first, by means of the torsion of a spring fixed lengthwise on the axis of one of the wheels; and secondly, by means of an air-fan. Although the regulation of the spring governor was correct in theory, it failed in practice, owing to the delicate nature of the principle, as soon as varying resistances had to be overcome. In both the systems referred to the motive power was a weight.

In a third arrangement adopted by the Astronomer Royal, water is used as a motive power and regulator; the resultant motion being controlled, in addition, first by a conical pendulum, and secondly, by Siemens' chronometric arrangement.

My attention has lately been specially directed to these various arrangements, as it has become necessary to construct a driving-clock for the Great Refractor. The defects of the two former systems were so strong to my mind, that the arrangement now brought before the notice of the Society was devised to replace them. The regulator adopted in this driving-clock is the vibrating pendulum, because, amongst the means at the mechanician's command for obtaining perfect time-keeping, there is none other by which the same degree of accuracy can be obtained. The difficulty in this construction is the conversion of the jerking or intermittent motion produced by such pendulums into a uniform rotatory motion, which can be available *with little or no disturbing influence on the pendulum itself*, when the machine is subject to varying frictions and forces to be overcome in driving large equatoreals. This was the difficulty proposed to be met by Bond's Spring Governor. It is met in the new one by the principles and mechanical arrangements described below.

1. The pendulum is a half-second one, with a heavy bob, adjusted by sliding the suspension through a fixed slit. It is drawn up and let down by a lever and screw, the acting length of the pendulum being thus regulated. The head of this screw is made large and grooved, and holds an endless cord, by which the observer can at once regulate the speed.

2. The scape-wheel is a double one, each wheel having four teeth; the pallets are round steel pins, producing nearly a dead beat, and work between the two scape-wheels. The teeth of one wheel strike one pallet; the teeth of the other wheel on the other pallet. A small amount of recoil is purposely given. The wheel makes one revolution in eight vibrations or in four seconds.

3. The arrangement of the wheels represents something like

the letter U. At the upper end of one branch is the scape-wheel. At the upper end of the other branch is an air-fan. The large driving-wheel and barrel are situated at the bottom or bend. All the wheels are geared together in one continuous train, which consists of eight wheels and as many pinions. The scape-wheel and the two following wheels have an intermittent motion. All the others have a continuous and uniform one.

4. The change from one motion to the other is made at the third wheel, which, instead of having its pivot at the end of the arbor where the wheel is fixed—fixed to the frame like the others—is suspended from above by a long arm having a small motion on a pin fixed to the frame, the pivot at the other end of the arbor is fixed to the frame as the others are, but its hole and its pivot are arranged so as to permit a very small horizontal angular motion round them, as a centre, without interfering with the action of the gearing of the wheel itself.

5. The wheel with its suspended pivot has nothing to do in changing the relative speed of the wheel and pinion into which it is geared, but it acts as a kind of '*remontoire*.' Supposing, for instance, the wheel below it, into which it is geared, is stationary; a force applied horizontally at the pivot would cause this remontoire wheel to *roll* on the one below it, and to give motion to the wheel and scape-wheel above it.

6. The suspending piece which carries the movable pivot and remontoire wheel has projecting from it, inwardly, a branch, which, while the clock is in motion, presses against a spring fixed horizontally and pivoted to the frame; the other end of which is made slender, and imparts a gentle pressure on a smooth wheel rapidly revolving, in order that a small amount of friction will have a great regulating power.

7. If the weight is applied to the clock when the pendulum is not vibrating, the force of the weight tends to give motion to the wheel below the remontoire one, and to all the wheels up to the air-fan; the spring is gently forced against the friction-wheel, and then prevents any further motion of the train. The spring in this position pushes the movable pivot outwards, and makes the remontoire wheel tend to move the one above it, and through it the scape-wheel.

8. If the weight is applied to the clock, and the pendulum is made to vibrate, the moment it begins to move, the scape-wheel moves its quantity for a beat; the remontoire wheel, by the very small force outwardly caused by the reaction of the break-spring, relaxes its pressure against the friction-wheel, and sets at liberty the train of the clock.

9. The spring is now driven back to the break-wheel, but before it can produce more than the necessary friction to keep the train in uniform motion, another beat of the clock again releases it. The repetition of these actions produces a series of impulses on the break-wheel of such a force and nature as to keep the train freely governed by the pendulum.

10. The small motion of the remontoire wheel pivot* to and fro is equal only to about $\frac{1}{100}$th of an inch.

The above description will give a general idea of the arrangement adopted; it may be mentioned that instead of friction produced by a spring, the remontoire wheel may be made to act on an air-fan inclosed in a box, through the openings in the periphery of which, more or less air will be allowed to pass according to the force of the train.

The uniform rotatory motion obtained by this clock as far as experiments can be made by applying widely different weights, and comparing the times with a chronometer, is perfectly satisfactory.

A clock constructed on the same principle, connected with, and giving motion to, a cylinder, will, it is presumed, make an excellent chronograph.

Southampton Street, Strand,
May 13, 1868.

On a persistent Marking on Jupiter. By J. Browning, Esq.

The first in order of date of the two drawings of *Jupiter* which I have now the honour to submit to the Society, was made on Sept. 12, 1867, at 10·15 P.M., with the Barnes $10\frac{1}{4}$-in. reflector, power 200. The second drawing was made with my own $12\frac{1}{4}$-in. reflector, same power, on Dec. 22, 1867, at 5.30 P.M. On both these drawings a dark belt, to the N. of the bright equatoreal cloud-belt, will be seen to have a rather uniformly corrugated appearance on the lower or northern edge.

This corrugation I have represented on the diagram I have here, which is enlarged from one of the drawings. During the interval between taking the two drawings, I frequently saw the marking I have described, whenever the air was sufficiently steady to allow me to use powers above 100.

I am well aware that markings on *Jupiter* have been observed to remain almost unchanged for some months at a time. But my reason for directing attention to this particular marking is that I have noticed, that in Mr. De La Rue's well-known beautiful drawing of *Jupiter* taken in October 1856, a marking greatly resembling this is shown in exactly the same position.* I am therefore, inclined to think that this mark may possibly indicate the conformation of the surface of the planet, or at least some peculiar condition of this portion of the planet's atmosphere.

* The mark can only be recognised in Mr. De La Rue's own engraving from his drawing, it is not shown in any of the numerous woodcuts which have been copied from it.

Observations of the Zodiacal Light. By Major Tennant.

Jan. 23. Lat. about 17° 30′, N.—Conspicuous but ill-defined vertex about half way between 4 and *α* Tauri and 3° N. of line.

Jan. 27.—Not so bright and more confused. Lat. 12° N. The bright light has its vertex near *μ Piscium*, and it is more faintly traceable to ξ^1 *Ceti*.

Jan. 28.—Moonlight. Lat. 11° 30′. Traceable notwithstanding young Moon to *ε Piscium*.

Jan. 29.—*Venus* seen easily at half an hour after noon. *Jupiter* invisible.

Feb. 10, *Madras*.—Moonlight compelled observations too early in evening, but traced Zodiacal Light to near *δ Arietis*.

On Saturday, February 23, the vertex of the Zodiacal light was not visible, the light merged in that of the borders of the Milky Way. I have never seen any appearance of angularity in the light. I have watched it from sunset at intervals till 9 P.M., and after the glow of sunset was gone have always found the shape a portion of a long ellipse, or parabola, ill defined at the outlines, and fading away, and with a marked condensation of light towards the axis and horizon. I will endeavour to estimate the position of the axis in future, but it is very difficult to place the lower end among the stars. The brightness of *Venus* much interferes with observation of that part till it has set.

Calcutta, March 1, 1868.

Occultation of γ Tauri, 28 *March*, 1868. By John Joynson, Esq.

Lens $3\frac{1}{2}$-in., Power 60.

	h m s	
Disappearance	9 2 48·5	G.M.T.
Reappearance	9 58 20·4	,,

At the disappearance the dark limb of the Moon was clearly seen, and in both cases the time was deemed exact.

	h m s	
Long.	0 12 7	W.
Lat.	53° 28′ 24″	N.

Waterloo, near Liverpool,
April 3, 1868.

Eclipses of Jupiter's Satellites, observed at Windsor, New South Wales. By John Tebbutt, Jun. Esq.

The accompanying observations of Eclipses of *Jupiter's* Satellites were made with a refractor of $3\frac{1}{4}$ inches aperture and 4 feet focal length. A magnifying power of about 90 was employed in the observations of July 20th, 24th, and 25th, 1867; but, in all the other observations a power of 120 was used. The times were noted by means of an eight-day half-seconds chronometer of Parkinson and Frodsham's construction. The last column contains a comparison of the observed times with those in the *Nautical Almanac*, the longitude employed for the comparison being $10^h\ 3^m\ 15^s\!\cdot\!7$ E. Signals by electric telegraph exchanged between Mr. Smalley and myself, give $1^m\ 30^s\!\cdot\!04$ as the longitude of my Observatory *west* of the Sydney Observatory. The longitude of the latter, finally deduced by the Rev. W. Scott from comparisons of the Sydney Moon culminations with corresponding observations at Greenwich in 1860 and 1861, and at the Cape of Good Hope in 1859, is $10^h\ 4^m\ 45^s\!\cdot\!7$ E. of Greenwich: (see the vol. of *Sydney Astronomical and Meteorological Observations* for 1861). $10^h\ 4^m\ 45^s\!\cdot\!7$ *minus* $1^m\ 30^s\!\cdot\!0$ gives $10^h\ 3^m\ 15^s\!\cdot\!7$, therefore, as the longitude of my Observatory *east* of Greenwich. I may mention that twenty-six transits of the Moon's first limb and four of the second observed here in 1866, and compared with the *Nautical Almanac*, give $10^h\ 3^m\ 19^s\!\cdot\!1$ E., and eighteen of the first limb in 1867, $10^h\ 3^m\ 23^s\!\cdot\!1$ E. as the approximate longitude. These culminations were observed by means of a Transit of 2·1 inches aperture, mounted on a substantial pier, and the chronometer above mentioned.

The following correction should be made in my observations of η *Argûs*, published in page 83 of the 26th vol. of the *R. A. S. Notices*:—

In the 12th line from the bottom, *for* 1818, *read* 3818.

Eclipses of Jupiter's Satellites, observed at Windsor, New South Wales, in the years 1866 *and* 1867.

Date.	Satellite.	Phase.	Windsor M.T.	App. Error of Naut. Alm.
1866.			h m s	m s
June 4	I.	Disappearance	11 27 50·5	−0 3·9
28	II.	ditto	9 36 14·6	−0 26·4
28	III.	ditto	11 22 22·8	+0 33·5
July 6	I.	ditto	8 1 25·5	+0 35·9
23	II.	Reappearance	9 22 49·6	+0 7·1
Aug. 17	II.	ditto	6 25 39·9	+0 54·4
24	II.	ditto	9 2 6·4	+0 18·5
Sept. 6	I.	ditto	9 3 59·2	−0 16·6
8	III.	ditto	6 47 19·2	+3 9·0

Date.	Satellite.	Phase.	Windsor M.T.	App. Error Naut. Alm.
1866.			h m s	m s
Sept. 13	I.	Reappearance	10 59 6·9	−0 3·0
15	III.	Disappearance	7 23 0·5	+1 46·1
15	III.	Reappearance	10 48 8·2	+3 32·5
18	II.	ditto	6 9 28·9	+0 3·2
22	I.	ditto	7 23 22·8	−0 7·9
25	II.	ditto	8 46 23·8	−0 3·4
Oct. 15	I.	ditto	7 38 33·0	−0 13·4
Nov. 14	I.	ditto	9 49 2·6	−0 43·8
Dec. 3	III.	ditto	7 3 49·9	+0 23·5
1867.				
July 20	III.	Disappearance	11 38 0·1	+0 22·0
24	II.	ditto	8 54 4·0	−0 6·8
25	I.	ditto	9 36 42·9	+0 4·1
27	III.	ditto	15 36 57·6	+1 42·7
31	II.	ditto	11 28 6·8	+0 30·0
Aug. 1	I.	ditto	11 30 55·3	+0 24·8
10	I.	ditto	7 54 21·6	+0 23·8
17	I.	ditto	9 49 20·4	+0 15·5
30	IV.	Reappearance	6 19 32·6	+0 7·3
Sept. 18	I.	ditto	8 43 14·2	−0 1·2
Oct. 7	III.	ditto	11 17 29·2	+1 34·5
11	I.	ditto	8 59 42·8	−1 6·4
18	I.	ditto	10 54 14·3	+0 1·4
19	IV.	Disappearance	8 32 9·0	+6 40·2
19	IV.	Reappearance	12 52 19·7	+0 39·3
21	II.	ditto	8 1 33·9	−0 53·5
Nov. 5	IV.	ditto	7 7 52·9	−2 50·2
19	I.	ditto	7 35 0·9	−0 2·2
19	III.	Disappearance	8 4 23·8	+1 32·6
22	II.	Reappearance	7 46 49·7	−1 40·2
Dec. 12	I.	ditto	7 51 15·6	−0 26·0

Remarks.

1866.

June 4. Good observation; definition very good.

28. Full Moon present. The disappearance of the II. Satellite was observed in clear sky; that of the III. Satellite through a thin cirrus cloud.

July 6. Planet ill defined and boiling. Final disappearance noted; the satellite had disappeared and reappeared a few seconds earlier.

23. Definition very good, but time probably rather late, owing to proximity of satellite to planet's limb.

Aug. 17. Excellent definition.

24. Night beautifully clear, but Moon near her opposition, and not far from planet. Good observation.

Sept. 6. Thin clouds flying across planet, but images bright and well defined at reappearance.

1866.
Sept. 8. Night calm, and beautifully clear.
13. Calm, and sky beautifully clear. Definition very good.
15. Sky very clear. Telescope vibrated slightly at disappearance, but definition pretty good. Excellent definition at reappearance.
18. Observation during twilight, the Sun's upper limb having disappeared below the horizon just 23·3 minutes previously. Sky beautifully clear, and definition good. Moon in first quarter, and not far from planet.
22. Definition pretty good.
25. Good definition.
Oct. 15. Night beautifully clear, and definition very good.
Nov. 14. Imperfect observation through cloud. Planet rather low and near Moon.
Dec. 3. Satellite first perceived in the twilight at time noted; the other three satellites had shortly before become visible.
1867.
July 20. Very good definition, but Moon about 3° distant from planet.
24. Planet low, but definition good. I thought I could just perceive a faint trace of the satellite again for a moment six seconds after the time noted.
25. Excellent definition.
27. Sky hazy; bad observation.
31. Sky hazy; bad definition.
Aug. 1. Clear sky; good definition.
10. Planet boiling; observation unsatisfactory.
17. Sky clear about planet, but Moon present. Definition pretty good, but images rather tremulous.
30. Sky cloudless, but twilight had scarcely disappeared. Planet low and boiling.
Sept. 18. Clear calm night.
Oct. 7. Good observation. Definition pretty good, but Moon present.
11. Moon present, and sky overspread with thin cloud.
18. Excellent definition, but observation probably a second or two late.
19. Definition unusually good at disappearance, and immersion very gradual. Images not so well defined at reappearance, and somewhat tremulous. Observation, however, pretty good.
21. Sky clear, and definition pretty good.
Nov. 5. Unsatisfactory. At the time noted the satellite was plainly distinguishable, and almost in contact with another satellite. The fourth satellite came out so nearly in a visual line with the other as to be hardly distinguishable from it for some time.
19. Excellent definition in both cases, but the disappearance was very gradual.
22. Sky very hazy.
Dec. 12. Sky very clear. Definition good, but images rather tremulous.

Windsor, New South Wales,
February 28, 1868.

Further Notice of the Lunar Crater Linné.
By the Rev. T. W. Webb.

Since the communication of my previous remarks on this object, I have fortunately obtained an observation which I hope may be thought worthy of the honour of being laid before the Society.

1868, March 30. $9\frac{1}{3}$-inch silvered glass speculum; definition generally unsteady, with a tendency to double images, but at intervals quiet and clear. Terminator through the "pass" between *Caucasus* and the *Apennines*: the ring of *Cassini* coming into sight.

Linné was speedily made out with 450 as a minute black crater elongated N. and S. with a very narrow wall; the brightest part of the whole object being the rise of the *glacis* on the W. side. 212 had barely power enough; but at times the little black crater was quite certain. Single lens about 275, certain and clear at times. 450 again; sometimes very plain, at others blurred. I see plainly the traces of the white cloud, and that *Linné* (the minute crater) is central. The crater is barely half the size of *Linné* A. Afterwards it was extremely distinct with 212, and could be glimpsed with 170. The commencement of the white cloud was very evident with 65.

I am confident that, under the present illumination, there is nothing visible on the site of *Linné* but the minute crater, and the traces of the cloud.

The occasional clearness of definition was proved by my first sight of a very difficult object, obligingly mentioned to me by Mr. Knott, the minute crater on *Posidonius* γ; which I could see with 450, and afterwards 212 showed me at times even its very narrow ring.

On the two following nights the black crater of *Linné* diminished, as the white cloud increased, in visibility: on neither occasion was the definition equal to that of the 30th.

Though the command of the object which I possessed on the 30th left no doubt whatever on my mind, it was with great pleasure that I received the following confirmation from Mr. With of Hereford, who had been observing the Moon on the same night:—

"Definition unsteady, but wonderfully sharp at times: a tendency to double image from atmospheric disturbance. Aperture $12\frac{1}{8}$-inches silvered glass; focus $6\frac{1}{2}$ feet; power $300 \pm$. During moments of steady vision the crater of *Linné seen* as a black spot surrounded by a narrow brilliant ring. Ring considerably brighter than the 'cloud.' Crater not round—elongated N. and S. Seen several times during a period of about 30 minutes."

The accurate eye and the extraordinary optical advantages employed in this latter observation induce me to hope that the Society will accept the verification as one of no ordinary value,

especially as regards the elongated form. On the night in question I was under an impression that it had been so delineated by Mr. Huggins, but this I find was a mistake, and I am not aware that it has been so seen by any previous observer.

Hardwick Parsonage, April 13, 1868.

On the Lunar Crater Linné. By C. L. Prince, Esq

I beg to communicate to the Society the following observations respecting the Lunar Crater *Linné:*—

1867, July 8th. With a power of 140 on my telescope of 6·8 inches aperture and 12 feet focal length, *Linné* presented a cloudy appearance only; but, with the power increased to 378, I could, by glimpses, distinguish the small black Crater.

July 9th. *Linné* appeared as a cloudy spot.

July 10th. The small black circular crater easily visible; but the definition was not good enough to enable me to trace the edge of external shallow one.

Aug. 8th. *Linné* merely a cloudy spot.

Nov. 3d. With a power of 288 I saw *Linné* to great advantage this evening, as a fairly defined crater, within which was an elevation, having a small circular crater on its summit. A thin line of shadow was visible within the western wall. The eastern wall was occasionally visible, but its elevation appeared very trifling.

1868, March 1st. I observed *Linné* very satisfactorily for about twenty minutes before the Moon was obscured by clouds. The shallow crater was distinctly visible on the western side, but not on the eastern. The western slope of the somewhat conical elevation had a very rugged surface and an overhanging crag near the top. It was brilliantly illuminated by the strong Sunlight to the very edge of the small crater, which was encircled by a ring of metallic lustre. I again observed that this little crater is both circular and deep; the interior shadow being very dark. The usual cloudiness was not seen, and the general colour of the *Mare* was maintained to the wall of the shallow crater.

On the following evening *Linné* was merely a cloudy spot.

May 1st. The Moon being nine days old, and *Linné* far removed from the terminator, I was not a little surprised to see the small crater beautifully distinct, about 7 P.M. It appeared, as heretofore, perfectly circular; its interior shadow as black as it was on March 1st, and in fine contrast with its bright edge. Its depth must be very remarkable, considering the elevation of the Sun on the ninth day of the Moon's age. Very little cloudiness was visible, and this gradually disappeared as I increased the magnifying power from 140 to 430. The atmosphere at 8 P.M. was so diaphanous that I was able to use rather high powers to

great advantage. The ascent from the base of the central elevation to its summit is much shorter and more precipitate on the western than on the eastern side. The position and appearance of the small crater, given by Mr. Huggins, at page 296, vol. xxvii. of the *Notices*, appear to me very correct, had its diameter been a little larger.

Although the definition was unusually fine from 7 to nearly 9 P.M., on the 1st inst., yet at 10 P.M., in consequence of the wind having shifted suddenly to the eastward, it became so bad that the whole of *Linné* was at once converted by it into a confused, cloudy, white patch, without a trace of the crater being visible.

Various observations of my own and others now lead me to the belief that no physical change has taken place in any part of *Linné*, and that the different aspects which it has presented to different observers must be ascribed to the ever-varying conditions of our own atmosphere.

Observatory, Uckfield, May 6, 1868.

Note on the Lunar Crater Linné. By Mr. Birt.

Linné.—The observations made on the 30th March last, which have come under my notice, are so interesting that I am induced to submit a synopsis of them with a view of soliciting further attention to this now remarkable object.

The white spot was observed as such by Messrs. Key, Webb, Buffham, and Crossley.

Mr. Crossley remarks that the obscuration round the crater appeared circular, and somewhat dished, but badly defined at the edges.

The large shallow crater was observed by Capt. Noble (*Monthly Notices*, vol. xxviii. p. 187), and by Mr. Huggins, who describes the western wall as much higher than the other. (*Report of the Proceedings of the R. A. S. in Astronomical Register*, No. 65, p. 103.)

The small crater was seen by the Rev. H. C. Key, who speaks of it as being situated on the summit of a gradually rising mound; the Rev. T. W. Webb, who saw it elongated N. and S., black inside, sharp narrow ring. Mr. Webb adds, that his observation was confirmed by Mr. With. Mr. Crossley's observations will be found in the *Monthly Notices*, vol. xxxviii. p. 187. It was also seen by Mr. Huggins; see *Astronomical Register*, as above. Mr. Buffham saw a round bright spot towards the W. side, about $\frac{1}{4}$ (or a little more) of the diameter of the light circle, with a kind of gray shading near the middle of the white spots E. of the bright spot as shown by his sketch. A correspondent (T. P.) of the *Register* says that *Linné* was seen of a small crater form with a central black spot surrounded by a thin bright ring.

By the period of similar phase, viz. $59^d\ 1^h\ 28^m$, after which interval the terminator will pass over nearly the same portion of the Moon's surface; the variation of the Sun's declination at the Moon slightly changing the angle which the terminator makes with the meridian—*Linné* will be almost similarly situated with regard to the terminator, on May 28, 1868, a slight alteration in the Sun's altitude being produced.

An interval of 442 days 23 hours will again bring the terminator very near *Linné*, about an hour earlier than the time of the observations of March 30. This will occur in 1869, on the evening of June 16, when the angle of illumination will be nearly similar; the Sun in the mean time having passed its greatest S. declination, and approached the Moon's equator; its declination at the Moon never exceeds $1^\circ\ 32'\ 9''$. The quantities stand as under :—

1868	March 30	$\odot - \Omega = 217^\circ\ 13'.5$	S dec. approaching Solstice
	May 28	$\odot - \Omega = 277\ 38.1$	S dec. past Solstice
1869	June 16	$\odot - \Omega = 315\ 54.1$	S dec. approaching Equinox.

On the last two mentioned days, other circumstances being equal, *Linné* may be expected to present similar phenomena to those noticed on March 30, so far as illuminating angle is concerned. Libration will, however, affect the visual angle, and should good observations be obtained, it may be worth while to compute the effect produced by the variation of the two angles.

Cynthia Villa Observatory, Walthamstow,
1868, *May* 5.

Ephemeris of Brorsen's Comet. By Dr. C. Bruhns.
Perihelion passage 1868, April 18·4393.

1868. 0ʰ Berlin T.	α h m s	δ ° ′	Log. r	Log. Δ
May 10	5 58 51	+ 44 20·8	9·8701	9·9830
11	6 7 16	45 3·9		
12	15 55	45 44·8		
13	24 48	46 23·3		
14	33 54	46 59·3	9·8963	9·9721
15	43 14	47 32·6		
16	52 46	48 3·0		
17	7 2 29	48 30·4		
18	12 24	48 54·6	9·9224	9·9643
19	22 28	49 15·8		
20	32 40	49 33·5		
21	42 59	49 47·7		
22	53 22	49 58·5	9·9480	9·9600

1868. Berlin T.	α h m s	δ ° ′	Log. r	Log. Δ
May 23	8 3 49	50 5·6		
24	14 17	50 9·3		
25	24 44	50 9·3		
26	35 9	50 5·9	9·9728	9·9593
27	45 29	49 58·9		
28	55 43	49 48·6		
29	9 5 48	49 35·0		
30	15 44	49 18·2	9·9966	9·9622
31	25 29	48 58·3		
June 1	35 2	48 35·6		
2	44 22	48 10·2		
3	53 28	47 42·3	0·0194	9·9688
4	10 2 19	47 12·0		
5	10 54	46 39·5		
6	19 15	46 5·0		
7	27 20	45 28·8	0·0411	9·9786
8	35 9	44 50·9		
9	42 43	44 11·5		
10	50 2	43 30·9		
11	10 57 5	+ 42 49·2	0·0617	9·9913
12	11 3 54	42 6·5		
13	10 29	41 23·1		
14	16 51	40 38·9		
15	22 59	39 54·1	0·0813	0·0067
16	28 54	39 8·8		
17	34 57	38 23·2		
18	40 8	37 37·3		
19	45 27	36 51·4	0·0999	0·0237
20	50 36	36 5·5		
21	55 35	35 19·6		
22	12 0 24	34 33·9		
23	5 3	33 48·3	0·1177	0·0424
24	9 34	33 2·9		
25	13 56	32 17·9		
26	18 10	31 33·2		
27	22 17	30 48·8	0·1346	0·0622
28	26 17	30 4·8		
29	30 9	29 21·2		
30	33 55	28 38·1		
July 1	37 34	27 55·4	0·1506	0·0829
2	41 7	27 13·2		
3	44 35	26 31·6		
4	47 57	25 50·5		
5	51 14	25 10·0	0·1660	0·1040

1868. Berlin T.	α h m s	δ ° ′	Log. r	Log. Δ
July 6	54 26	24 30·0		
7	57 34	23 50·5		
8	13 0 37	23 11·6		
9	3 37	22 33·2	0·1806	0·1252
10	6 33	21 55·4		
11	9 24	21 18·2		
12	12 12	20 41·5		
13	14 58	20 5·4	0·1947	0·1466
14	17 40	19 29·8		
15	20 19	18 54·8		
16	22 55	18 20·3		
17	25 28	17 46·4	0·2081	0·1677
18	27 58	17 13·0		
19	30 26	16 40·1		
20	32 51	16 7·8		
21	35 14	15 36·0	0·2209	0·1887
22	37 35	15 4·6		
23	39 54	14 33·8		
24	42 11	14 3·4		
July 25	13 44 25	+ 13 33·6	0·2333	0·2092
26	46 38	13 4·2		
27	48 49	12 35·3		
28	50 58	12 6·9		
29	53 6	11 39·0	0·2451	0·2293
30	55 12	11 11·4		
31	57 17	10 44·3		
Aug. 1	59 21	10 17·6		
2	14 1 23	9 51·5	0·2565	0·2489
3	3 24	9 25·7		
4	5 23	9 0·2		
5	7 21	8 35·2		
6	9 19	8 10·6	0·2675	0·2679
7	11 15	7 46·4		
8	13 10	7 22·5		
9	15 4	6 59·0		
10	16 57	6 35·9	0·2780	0·2865
11	18 49	6 13·1		
12	20 40	5 50·7		
13	22 30	5 28·6		
14	24 20	5 6·8	0·2882	0·3044

Instruments for Sale.

A Refractor, of 8 inches aperture and 10 feet focal length, mounted equatoreally by Cooke and Sons, with circles finely divided in silver; driving clock, &c., complete. The object-glass, by Alvan Clarke, is a very fine one, and was formerly in the possession of the late Rev. W. R. Dawes. The instrument is at present mounted in the Observatory of Mr. Huggins, at Upper Tulse Hill, to whom application is to be made.

A 7-foot Equatoreal, by Simms. Aperture 4·9 inches; declinated circle, 18 inches; hour circle, 15 inches; also an 18-inch transit circle. Apply to the Rev. J. Slatter, Streath Vicarage, Berks.

ERRATUM.

P. 6, line 12, *dele* previously.

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MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. XXVIII. *June* 12, 1868. No. 8.

Admiral MANNERS, President, in the Chair.

C. H. H. Cheyne, Esq., 1 Dean's Yard, Westminster;
Henry Wm. Hollis, Esq., Ormston Manor, Derby;
Wm. Rossiter, Esq., Collingwood Street; and
Robert Wm. Skiffington Lutwidge, Esq., Barrister-at-Law,

were balloted for and duly elected Fellows of the Society.

On the Variable Star η Argûs and its Surrounding Nebula. By Sir J. F. W. Herschel, Bart.

The changes recorded by Mr. Abbott, in his communications to this Society, published in vols. xxiv. and xxv. of the *Monthly Notices*, and more especially in the *Notice* which has just appeared (vol. xxviii. p. 200), are so very astonishing that it is high time the attention of every astronomer in the southern hemisphere provided with instruments at all competent to show, I will not say all the details—but—the brighter portions of the nebula, should be directed to its delineation, and to the relative situations of every star within 10′ or 15′ of the principal star. There is no phenomenon in nebulous or sidereal astronomy that has yet turned up, presenting anything like the interest of this, or calculated to raise so many and such momentous points for inquiry and speculation. The question here is not of minute variations in subordinate features, which may or may not be attributable to differences of optical power in the instruments used by different observers, as in the case of the nebula in *Orion* (the only one comparable to it in magnitude, complexity, and brightness), but of a total change of form and character—a complete subversion of all the greatest and most striking features—accompanied with an amount of relative

movement between the star and the nebula, and of the brighter portions of the latter *inter se*, which reminds us more of the capricious changes of form and place in a cloud drifted by the wind than of anything heretofore witnessed in the sidereal heavens. In fact, not only as compared with the appearance of the nebula in 1834–7, which my delineations record, does Mr. Abbott's diagram of 1868 exhibit so astonishing a dissimilarity; but, when compared with the drawing given by himself at so recent a date as 1863 (vol. xxiv. p. 5), the difference is such that no one could possibly suppose the two representations referred to one and the same object.

η *Argûs* itself, though a variable star of the most extraordinary character, is nearly devoid of proper motion: the annual change due to this cause, in R.A. and N.P.D., as given in the Catalogue of the British Association, being only $-0^{\text{sec.}}\cdot001$ and $-0''\cdot09$, so that it is entirely owing to movements going on within the nebula itself that the change must be owing. But here comes the most astonishing part of the whole affair. The neighbourhood of η *Argûs* is thickly sown over with small stars. Of these, within the compass of a little more than a square degree, having η in the middle, I determined in 1834–7 the situations and apparent magnitudes of upwards of 1200; and, during all the course of my observations, never found reason to suspect the situations of any of these to be variable either *inter se* or with respect to η. Now Mr. Abbott's figure, as given in the recent Number of the *Monthly Notices*, shows this star accompanied by 150 stars of various magnitudes within a field of view (so I interpret the subscript figures $1^\circ\ 07'\ 47''$) of $1^\circ\ 8'$; and of these I have not been able satisfactorily to identify any one individual with any one in my Catalogue.

To be quite satisfied on this point, I laid down upon his figure a set of lines corresponding to the meridians and parallels of my chart,* being guided in their direction by the letters N S and E W (which I presume to express the situations of the North and South, and East and West points of his field of view at the moment of delineation); in their distance from each other in P D. by the diameter 68′ of the circle, containing exactly 17 intervals of 4′, the distance between the parallels on my chart ($4' = 1000$ micrometer parts), and in R.A. so as to correspond in due proportion to the intervals of $50^{\text{sec.}}$ of time between my meridians. This done, the places of Mr. Abbott's principal stars (within the limits of my chart) were read off as nearly as the small scale of the figure would allow, and are here set down — the magnitudes assigned being according to the best judgment I could form, from the size of the dots expressing them in the engraving, taking η itself as 6 mag. As regards the larger stars, this can hardly be very erroneous, though, as respects the smaller ones, no conclusion can be formed, since, though Mr. Abbott

* "Cape Observations," Plate ix.

states the *focal lengths* (5 feet) of the telescopes he used, he nowhere mentions their apertures.

Star's Mag.	Δ R.A. from η in Seconds of Time.	Δ.N.P.D. from η in Microm. parts, each = 0″·004.	Star's Mag.	Δ.R.A. from η in Seconds of Time.	Δ.N.P.D. from η in Micr. parts, each = 0″·004.
η = 6 m.	0	0	8 m.	−42	−1600
6 m.	−165	−5950	7.8 m.	+30	+5200
9 m.	−147	−1750	7.8 m.	+45	+6000
9 m.	−120	−1400	8 m.	+77	−450
8 m.	−55	−900	8 m.	+80	+400
8 m.	−45	−1850	8 m.	+87	−1250

The following are the principal stars within the limits of Mr. Abbott's field of view, as given in my Catalogue*:—

Star's Letter and Mag.	Δ.R.A. from η in Seconds of Time.	Δ N.P.D. from η in Microm. parts = 0″·004.	Star's Letter and Mag.	Δ.R.A. from η in Seconds of Time.	Δ.N.P.D. from η in Micr. parts = 0″·004.
η = 2 m.	0	0	λ = 8 m.	+ 37·8	−4143
ω = 8 m.	−148·0	−1332	δ = 8 m.	+ 66·7	−5486
O = 7 m.	− 65·5	−2025	σ = 9 m.	+ 78·9	+5014
C = 8 m.	− 51·6	+ 539	κ = 8 m.	+155·9	−1726
U = 7 m.	− 38·5	+4627	W = 6 m.	+158·3	+2782
D′ = 8 m.	− 29·1	+ 860	γ = 7 m.	+178·9	+3441
D = 8 m.	− 28·8	+ 798			

The utter disagreement of these two lists of the principal stars is apparent, and renders it unnecessary to go into a comparison of those of smaller magnitude.

Conceiving it possible, however, that the letters N, S, E, W, may be misplaced in Mr. Abbott's diagram, or that the nature of the inversion of his eye-piece may have been, by myself, misapprehended, I laid down, on the same scale, a miniature of my chart on thin paper, with the meridians and parallels, placing on it in their proper positions all the stars in this latter list. Then, oiling the paper so as to render it transparent, it was laid down on Mr. Abbott's diagram, the two stars η in each being brought to coincidence. Turning then the oiled chart round on the diagram, no situation could be found to bring about any tolerable coincidence of the stars in the one and the other. The same result was obtained when the oiled chart was reversed (laid *face downwards*) on the diagram, and turned round in the same way.

What then are we to conclude? Not only the nebulous masses would appear to have drifted far away from their situations in 1835, but the stars of the whole region over an area of nearly two-thirds of a square degree, including stars of the 6th, 7th, and 8th magnitudes, to have also either assumed new configurations *inter se*, or to have bodily fled away and given place to a new set!

* "Cape Observations," pp. 42. *et seq.*

Again, within a circle of 6′ radius round η, in Mr. Abbott's diagram occur 19 minute stars. In my chart, within a circle of the same radius, are laid down 57, of which two are of the 8th, four of the 10th, and two of the 11th magnitudes, but among all these not one can be satisfactorily identified with any of his. The best approach in general appearance is that of the line of five very small stars in close vicinity to η and to the immediate south of it, which may be considered as somewhat to resemble the crooked line of stars G, (ι), (ζ), (η), (θ), in my chart. But *these* are quite otherwise situated with respect to η, and their general direction makes an angle of 70° with the parallel (from *sp* to *nf*).—

Another very puzzling feature in Mr. Abbott's description is the brightness he ascribes to the nebula, which he states to "gives out fully twice as much light as that of the Nubecula major," "irrespective of size." How far the diminution of light in η from the 2d to the 6th magnitude may affect the visibility to the naked eye of the nebula in a dark night, I cannot pretend to say; but on no occasion do I remember to have perceived with the naked eye any nebulosity about it even in a dark night, and assuredly not in a twilight, such as just to allow stars of 2.3 mag. to become visible. *Such* a twilight effectually obliterates both the Nubeculæ, which, however, are both—the N. major especially—very conspicuous objects in a dark night.

It is much to be wished that some southern observer furnished with an equatoreally mounted telescope would *without further delay* set to work in earnest, and map down the stars visible within this most interesting area, down at least to the 10th or 11th magnitude. Possibly I may have done Mr. Abbott injustice by assuming that his diagram is intended to convey any *delineation* at all of the stellar contents of his field of view; or anything beyond the forms of the nebulous masses, as existing *among* scattered stars. But the question once raised is of the last importance and *must* be settled; especially in regard to what he himself says, *Monthly Notices*, vol. xxv. p. 4, as to the "increased number" [since 1837] "of brilliant isolated stars with a change in the position of η *Argûs*," as "the effect produced with a 5-foot achromatic;" in obvious reference to the *nebular hypothesis* of the formation of stars and planets by the condensation of nebulous matter. And this leads me to observe that, having taxed in vain my recollection as to the authorship of the passage which he there ascribes to me* on the subject of this theory, and not having

* "It will appear" . . . "that every succeeding state of nebulous matter is the result of the action of gravitation, and by such steps the successive condensation of it is brought to a planetary or stellar condition. Several instances are on record which connect the planetary with the stellar appearance. In those instances wherein the collection of nebulous matter was very extensive, subordinate centres of attraction could not fail to be established, around which the adjacent particles would arrange themselves, and thus the whole mass would in process of time be transformed into a determinate number of discrete bodies, which would ultimately assume the condition of a cluster of stars."—*Monthly Notices*, vol. xxv. p. 4.

succeeded in finding it in any of my published writings, I shall feel obliged to any friend who will refer me to the place where it occurs, as it certainly seems to convey a much more definite and decided view of the matter than I should *now* like to endorse.

Collingwood, June 8, 1868.

A determination of the Constant of Nutation from the observations in N.P.D. of Polaris, Cephei 51, *and δ Ursæ Minoris, made with the Transit Circle of the Royal Observatory, Greenwich,* 1851–1865. By E. J. Stone, Esq. (Abstract.)

The Transit Circle of the Royal Observatory, Greenwich, has been in regular use since the beginning of the year 1851, and the results, down to the year 1865 inclusive, are in the hands of astronomers. In the construction of the instrument no arrangements were provided for shifting the relative positions of the reading-microscopes, or the divisions under the microscopes, in any given position of the instrument. The same divisions are thus employed in the observation of a star for many years. This arrangement undoubtedly offers great advantages for the determination of a constant, like that of Nutation, where what we require is, that observations extending over many years should either be free from systematic error, or, which is quite as good for the present purpose, be affected only with constant errors. The division errors of the Greenwich Transit Circle were elaborately investigated in 1850 and again in 1857. The errors of the divisions under the microscopes, in the observations of the Nadir-point with the reflecting eye-piece, in the observations of *Polaris, Cephei* 51, and *δ Ursæ Minoris*, above and below pole, have also been separately investigated in 1857 and 1865.

The astronomical flexure of the telescope has been determined on the following occasions:—

Date.			Horizontal Flexure.
1850	Dec.	30	$+0''.41$
1851	Feb.	5	$+0.88$
1852	Dec.	23	$+0.20$
1857	Jan.	5	$+0.46$
1857	Jan.	21	$+0.66$
1860	Sept.	1	$+0.67$
1864	Sept.	7	$+0.76$

The mean value of the horizontal flexure $= +0''.58$.

1867	April	25	$-0''.34$
1867	May	8	-0.31
1867	May	13	-0.37

Mean value of the horizontal flexure $= - 0''\cdot34$.

In the autumn of 1865, the central cube of the transit-circle was pierced to allow of the adjustment of the wires of the collimating-telescopes on each other, without the necessity of first raising the transit-circle. In the operation of piercing the cube the state of strain of the instrument was so changed that the horizontal astronomical flexure of the instrument was found to be altered by nearly one second of arc. From the erection of the instrument to the time of piercing the cube, a discordance of a well-marked character had been observed between the nadir points, determined from observations with the reflecting eyepiece, and those resulting from observations of stars, north and south of the zenith, directly, and after reflexion at the surface of the quicksilver. With the change of sign in the flexure of the telescope, a change of sign in the law of the discordance R — D has also been shown by the observations of 1866 and 1867. If the discordances between the nadir-points arise from imperfect correction under the assumed law (= constant × sin Z D), a slight abrupt change in the resulting N.P.D. of a star may be expected to take place with the piercing of the cube. Such a change would, to a very considerable extent, be destroyed by the method adopted in the Greenwich reductions of applying a correction to the final results for the discordance R — D. I have, however, thought it better, for my present purpose, to keep entirely free from the necessity of applying any empirical correction such as that for R — D, and have therefore terminated the investigation with the date of piercing the cube. As all the observations after September 1865 were made with the altered flexure, I have not been able to employ the observations of *Polaris* made in the year 1865: the annual group for this year would not be strictly comparable with preceding annual groups.

The observations made use of have been extracted from the N.P.D. ledgers printed in the volumes of *Greenwich Observations*, 1851 to 1865. Different division errors, values of assumed horizontal astronomical flexure, and nadir-points deduced from a combination of reflecting-eye-piece determinations with results obtained from observations of stars by reflexion, have been employed in the reduction of the results as extracted directly from the ledgers. As the nadir-points employed are mixed up with the adopted flexure and adopted division errors, I have thought it better to reduce all the observations to nadir-points determined with the reflecting-eye-piece alone. The following Tables give the data employed in the reductions of different years, the data adopted, and the corrections required to reduce the material to one uniform system.

Colatitude used	1851 to 1854	38° 31′ 21″·80
	1855 to 1860	22·00
	1861 to 1865	21·80
Adopted colatitude		38 31 21·80

Corrections for Division Errors + Effect of Astronomical Flexure, as used in the Reductions.

	1851 & 1852.	1853 to 1856.	1857.	1858 to 1864	1865.
Nadir	+0″·86	+0″·63	+0″·76	+1″·02	+1″·20
Polaris	+0·69	+0·60	+1·07	+1·09	+1·14
Polaris S.P.	+0·92	+0·84	+1·18	+1·40	+1·45
Cephei 51	+0·72	+0·63	+0·99	+0·99	+1·05
Cephei 51 S.P.	+0·79	+0·72	+0·92	+0·92	+0·96
δ Ursæ Minoris	+0·81	+0·71	+0·94	+0·94	+1·00
δ Ursæ Minoris S.P.	+0·79	+0·72	+0·92	+0·92	+0·96

Corrections for Division Errors + Effect of Astronomical Flexure, adopted in this investigation.

Nadir		= +0″·75
Polaris		= +0·64
Polaris	S.P.	= +0·97
Cephei 51		= +0·73
Cephei 51	S.P.	= +0·45
δ Ursæ Minoris		= +0·64
δ Ursæ Minoris	S.P.	= +0·52

Numerical Corrections to the North Polar Distances of the Ledger Results.

	1851 & 1852.	1853 to 1856.	1857.	1858 to 1864.	1865.
Polaris	+0″·06	−0″·08	−0″·42	−0″·18	″
Polaris S.P.	−0·16	−0·01	+0·20	+0·16	
Cephei 51	+0·12	−0·02	−0·25	+0·01	+0·13
Cephei 51 S.P.	+0·23	+0·39	+0·46	+0·20	+0·06
δ Ursæ Minoris	−0·06	−0·19	−0·29	−0·03	+0·09
δ Ursæ Minoris S.P.	+0·16	+0·32	+0·39	+0·13	−0·01

The value of the nutation-constant employed in the reductions has been

9″·25 from 1851 to 1856 inclusive.
9″·224 from 1857 to 1865 „

The true value of this constant has been assumed

$$9''\cdot224 + x.$$

The following are the corrections for the effects of the precessional motion of the Earth's axis, which have been employed to reduce the mean N.P.D.'s for each year to the year 1858.

Year.	Polaris.	Cephei 51.	δ Ursæ Min.
	′ ″	″	″
1851	− 2 14·551	+ 18·839	− 11·792
1852	− 1 55·306	+ 16·281	− 10·025
1853	− 1 36·069	+ 13·678	− 8·284
1854	− 1 16·840	+ 11·031	− 6·570
1855	− 0 57·618	+ 8·339	− 4·884
1856	− 0 38·404	+ 5·603	− 3·228
1857	− 0 19·198	+ 2·824	− 1·600
1858	0·000	0·000	0·000
1859	+ 0 19·190	− 2·868	+ 1·572
1860	+ 0 38·372	− 5·780	+ 3·117
1861	+ 0 57·547	− 8·737	+ 4·634
1862	+ 1 16·713	− 11·738	+ 6·122
1863	+ 1 35·871	− 14·782	+ 7·581
1864	+ 1 55·021	− 17·871	+ 9·012
1865	+ 2 14·162	− 21·003	+ 10·415

Polaris.

Assumed mean N.P.D., Jan. 1, 1858,—

$$1^\circ\ 26'\ 51''{\cdot}222 + y.$$

Assumed proper motion in N.P.D. $= 0''{\cdot}00 + \delta p$.

The equations of condition for the yearly groups, are

Year.			w
		″	
1851	$y + 0{\cdot}7598\, x =$	$+ 0{\cdot}026 + 7\,\delta p$	32·06
1852	$y + 0{\cdot}7443\, x =$	$- 0{\cdot}034 + 6\,\delta p$	35·10
1853	$y + 0{\cdot}6324\, x =$	$- 0{\cdot}108 + 5\,\delta p$	26·46
1854	$y + 0{\cdot}4591\, x =$	$- 0{\cdot}180 + 4\,\delta p$	45·81
1855	$y + 0{\cdot}2174\, x =$	$- 0{\cdot}015 + 3\,\delta p$	33·23
1856	$y - 0{\cdot}0203\, x =$	$- 0{\cdot}026 + 2\,\delta p$	34·66
1857	$y - 0{\cdot}2739\, x =$	$- 0{\cdot}069 + \delta p$	45·75
1858	$y - 0{\cdot}4946\, x =$	$+ 0{\cdot}109$	57·44
1859	$y - 0{\cdot}6650\, x =$	$+ 0{\cdot}092 - \delta p$	52·50
1860	$y - 0{\cdot}7495\, x =$	$+ 0{\cdot}082 - 2\,\delta p$	30·37
1861	$y - 0{\cdot}7573\, x =$	$- 0{\cdot}082 - 3\,\delta p$	43·01
1862	$y - 0{\cdot}6678\, x =$	$+ 0{\cdot}093 - 4\,\delta p$	27·99
1863	$y - 0{\cdot}5180\, x =$	$+ 0{\cdot}093 - 5\,\delta p$	34·25
1864	$y - 0{\cdot}2978\, x =$	$+ 0{\cdot}017 - 6\,\delta p$	38·17

Multiplying each equation by the corresponding value of w,

and reducing the equations to two by the method of least squares, we have the following equations for the determination of y and x.

$$536{\cdot}80\,y - 84{\cdot}204\,x = +\,0''{\cdot}472 \quad + 211\,\delta p.$$
$$-84{\cdot}204\,y + 167{\cdot}257\,x = -\,14{\cdot}157 \quad + 913\,\delta p.$$

From which we deduce

$$x = -\,0''{\cdot}091 \quad + 6{\cdot}1\,\delta p$$

or Nutation constant $= 9''{\cdot}133 + 6{\cdot}1\,\delta p.$

Cephei 51.

Assumed mean N.P.D. Jan. 1, 1858,—

$$2^\circ\,44'\,59''{\cdot}8 + y.$$

Assumed proper motion in N.P.D. $= +\,0''{\cdot}08 + \delta c.$

The equations of condition for the yearly groups are

Year.		w.
1851	$y + 0{\cdot}413\,x = +\,0''{\cdot}538 \quad + 7\,\delta c$	3
1852	$y + 0{\cdot}074\,x = +\,0{\cdot}040 \quad + 6\,\delta c$	3
1853	$y - 0{\cdot}251\,x = +\,0{\cdot}090 \quad + 5\,\delta c$	3
1854	$y - 0{\cdot}563\,x = +\,0{\cdot}240 \quad + 4\,\delta c$	9
1855	$y - 0{\cdot}803\,x = +\,0{\cdot}470 \quad + 3\,\delta c$	5
1856	$y - 0{\cdot}948\,x = +\,0{\cdot}483 \quad + 2\,\delta c$	6
1857	$y - 0{\cdot}987\,x = +\,0{\cdot}464 \quad + \,\delta c$	5
1858	$y - 0{\cdot}923\,x = +\,0{\cdot}472$	12
1859	$y - 0{\cdot}722\,x = +\,0{\cdot}430 \quad - \,\delta c$	14
1860	$y - 0{\cdot}490\,x = +\,0{\cdot}156 \quad - 2\,\delta c$	8
1861	$y - 0{\cdot}166\,x = +\,0{\cdot}278 \quad - 3\,\delta c$	6
1862	$y + 0{\cdot}161\,x = +\,0{\cdot}296 \quad - 4\,\delta c$	3
1863	$y + 0{\cdot}480\,x = +\,0{\cdot}102 \quad - 5\,\delta c$	12
1864	$y + 0{\cdot}737\,x = +\,0{\cdot}076 \quad - 6\,\delta c$	11
1865	$y + 0{\cdot}918\,x = +\,0{\cdot}238 \quad - 7\,\delta c$	5

Multiplying each equation by the corresponding value of w, and reducing the equations to two by the method of least squares, we have for the determination of x and y the following equations,—

$$105\,y - 26{\cdot}157\,x = +\,30''{\cdot}470 \quad - 99\,\delta c$$
$$-26{\cdot}157\,y + 49{\cdot}778\,x = -\,16{\cdot}085 \quad - 133\,\delta c$$

From which we find

$$x = -0''\cdot196 - 3\cdot6\,\delta c$$

or Nutation constant $= 9''\cdot028 - 3\cdot6\,\delta e$.

δ *Ursæ Minoris.*

Assumed mean N.P.D. Jan. 1, 1858,—

$$3^\circ\ 23'\ 55''\cdot00 + y.$$

Assumed proper motion $-0''\cdot03 + \delta m$.

The equations of condition for the yearly groups are

Year.			w.
1851	$y - 0\cdot4546\,x = 1''\cdot507$	$+7\,\delta m$	9
1852	$y - 0\cdot1306\,x = 1\cdot526$	$+6\,\delta m$	9
1853	$y + 0\cdot1980\,x = 1\cdot530$	$+5\,\delta m$	4
1854	$y + 0\cdot5216\,x = 1\cdot597$	$+4\,\delta m$	9
1855	$y + 0\cdot7748\,x = 1\cdot444$	$+3\,\delta m$	4
1856	$y + 0\cdot9320\,x = 1\cdot260$	$+2\,\delta m$	4
1857	$y + 0\cdot9928\,x = 1\cdot458$	$+\ \delta m$	9
1858	$y + 0\cdot9464\,x = 1\cdot250$		9
1859	$y + 0\cdot7488\,x = 1\cdot347$	$-\ \delta m$	9
1860	$y + 0\cdot5524\,x = 1\cdot358$	$-2\,\delta m$	9
1861	$y + 0\cdot1780\,x = 1\cdot228$	$-3\,\delta m$	4
1862	$y - 0\cdot0990\,x = 0\cdot717$	$-4\,\delta m$	1
1863	$y - 0\cdot4236\,x = 1\cdot238$	$-5\,\delta m$	9
1864	$y - 0\cdot6977\,x = 1\cdot404$	$-6\,\delta m$	9
1865	$y - 0\cdot8958\,x = 1\cdot146$	$-7\,\delta m$	4

Multiplying each equation by the corresponding value of w, and reducing the equations to two by the method of least squares, we have the following equations for the determinations of y and x:—

$$102\,y + 23\cdot149\,x = 141\cdot314 + 32\,.\,\delta m$$
$$23\cdot149\,y + 44\cdot560\,x = 32\cdot588 + 76\,.\,\delta m$$

From which we find

$$x = +0''\cdot013 + 1\cdot75\,.\,\delta m,$$

or

$$\text{Nutation constant} = 9''\cdot237 + 1\cdot75\,.\,\delta m.$$

Taking the mean of the determinations of the Nutation constant from the observations of *Cephei* 51 and δ *Ursæ Minoris*, we find for its value

$$9''\cdot1325 + 0\cdot88\,\delta m - 1\cdot8\,\delta e.$$

This value agrees almost identically with the value resulting from the discussion of the observations of *Polaris*, viz.:—

$$9''\cdot133 + 6\cdot1 \,.\, \delta p.$$

Taking the mean of these values as our final result, we find for the Nutation constant,

$$9''\cdot133 + 3\cdot05\,\delta p + 0\cdot44 \,.\, \delta m - 0\cdot90 \,.\, \delta c.$$

From the care bestowed upon the reduction of the observations to one uniform system, I am inclined to lay much more stress upon apparently small changes than would otherwise have been the case. I have been much surprised, therefore, to find that the colatitudes resulting from the yearly means of the observations of *Polaris*, above and below pole, differ considerably from the general average in an apparently systematic manner.

The observations of *Cephei* 51 and δ *Ursæ Minoris* are neither sufficiently numerous nor sufficiently well distributed to give very accurate determinations of the colatitude from year to year. The observations of *Cephei* 51, however, appear to give changes of colatitude something similar to those given by the observations of *Polaris*. In the case of the observations of δ *Ursæ Minoris* the corresponding changes are not well shown, or they are disguised so as not to be easily recognizable. The following table gives the corrections to colatitude, resulting from the observations of *Polaris* above and below pole, for the years 1851 to 1865:—

Corrections to Colatitude deduced from the Observations of *Polaris* above and below the pole.

Year.	Correction.	Number of Observations Above Pole.	Below Pole.
1851	+0"·351	75	56
1852	+0·246	66	75
1853	+0·370	51	55
1854	+0·573	86	98
1855	+0·423	65	68
1856	+0·315	73	66
1857	+0·207	91	92
1858	+0·236	124	107
1859	+0·408	106	104
1860	+0·377	65	57
1861	+0·102	93	80
1862	+0·139	55	57
1863	+0·021	69	68
1864	+0·196	68	87
1865	+0·218	40	54

If we assume that the variation of these corrections depends upon the position of the Moon's Node, or correction

$$\begin{aligned}
&= z + r \cos (\Omega - q) \\
&= z + r \cos q \cos \Omega + r \sin q \sin \Omega \\
&= z + x \cos \Omega + y \sin \Omega,
\end{aligned}$$

we have the following equations for the determinations of x, y, z. The probable errors of the results will be considered as equal.

1851	$z - 0{\cdot}439\,x + 0{\cdot}891\,y = +\,0{\cdot}351$
1852	$z - 0{\cdot}141\,x + 0{\cdot}986\,y = +\,0{\cdot}246$
1853	$z + 0{\cdot}218\,x + 0{\cdot}972\,y = +\,0{\cdot}370$
1854	$z + 0{\cdot}519\,x + 0{\cdot}850\,y = +\,0{\cdot}573$
1855	$z + 0{\cdot}781\,x + 0{\cdot}618\,y = +\,0{\cdot}423$
1856	$z + 0{\cdot}933\,x + 0{\cdot}348\,y = +\,0{\cdot}315$
1857	$z + 0{\cdot}997\,x + 0{\cdot}019\,y = +\,0{\cdot}207$
1858	$z + 0{\cdot}948\,x - 0{\cdot}303\,y = +\,0{\cdot}236$
1859	$z + 0{\cdot}785\,x - 0{\cdot}613\,y = +\,0{\cdot}408$
1860	$z + 0{\cdot}561\,x - 0{\cdot}822\,y = +\,0{\cdot}377$
1861	$z + 0{\cdot}231\,x - 0{\cdot}968\,y = +\,0{\cdot}102$
1862	$z - 0{\cdot}119\,x - 0{\cdot}988\,y = +\,0{\cdot}139$
1863	$z - 0{\cdot}419\,x - 0{\cdot}903\,y = +\,0{\cdot}021$
1864	$z - 0{\cdot}697\,x - 0{\cdot}711\,y = +\,0{\cdot}196$
1865	$z - 0{\cdot}872\,x - 0{\cdot}487\,y = +\,0{\cdot}218$

These equations lead to the following for the determination of $x\,y\,z$:—

$$\begin{aligned}
15\,z + 3{\cdot}286\,x - 1{\cdot}111\,y &= +\,4{\cdot}182 \\
3{\cdot}286\,z + 6{\cdot}323\,x + 0{\cdot}912\,y &= +\,1{\cdot}447 \\
-1{\cdot}111\,z + 0{\cdot}912\,x + 8{\cdot}551\,y &= +\,0{\cdot}645
\end{aligned}$$

which give

$$\begin{aligned}
z &= +\,0{\cdot}270 \\
x &= +\,0{\cdot}074 \\
y &= +\,0{\cdot}103
\end{aligned}$$

The sum of the squares of the corrected residuals,

$$= 0{\cdot}164878.$$

If we apply the mean value of z only, the sum of the squares of the residuals will equal

$$0{\cdot}280152,$$

or the error of mean square has been reduced from $0''{\cdot}136$ to $0''{\cdot}105$.

If this evidence be considered sufficient to indicate an apparent periodical change in the colatitude of the Greenwich Observatory, it may perhaps be taken as a proof of the yielding of the Earth's crust under the Moon's action, or referred to a systematic deformation of the atmosphere arising from the same cause. Very slight changes in the inclination of the general direction of the effective strata of the atmosphere would be sufficient to produce in the colatitude apparent variations of the required amount. It may, perhaps, not be out of place to recall the attention of astronomers to the results of the Rev. R. Main's attempts to determine the annual parallax of γ *Draconis*.* From an elaborate discussion of the Greenwich Observations, extending over many years, made with two instruments of very different construction—Pond's Zenith Tube and Airy's Reflex Zenith Tube—the factor introduced to represent the annual parallax of γ *Draconis* came out a negative quantity. This anomalous result was deduced separately from a discussion of the observations with both these instruments.

Mr. Main's anomalous result for parallax might be explained by supposing that there exists a systematic deformation of the atmosphere with an annual period. The anomalies presented in the colatitude determinations from *Polaris* appear to be considerably diminished by supposing a systematic deformation of the atmosphere, with a period of 18 years. In this investigation an annual disturbance would, of course, be destroyed. It is curious, to say the least, that two investigations, which would appear the most favourable possible for the detection of systematic changes in the atmosphere, should each lead to anomalous results requiring apparently a very similar supposition for their explanation. I consider the discordances in the resulting colatitudes too systematic to arise from mere chance errors of observation.

Greenwich, 1868, *June* 12.

Observations of the Lunar Crater IV. A^{α} 17, IV. A^{ζ} 39. By W. R. Birt.

The extreme interest attaching to the crater *Linné* has induced me to submit to the Society the accompanying observations, principally made by the Rev. W. O. Williams of Pwllheli, North Wales, of a crater near the middle of the Moon, which has manifested similar phenomena, and I do so the more readily as having computed the solar altitudes for twelve hour intervals at the latitude of the crater, viz. 5° S., I have arranged the existing observations in the order of solar altitudes, commencing with sunrise at the equinoxes, by which it will be easily seen that below

* *Memoirs*, vol. xxiv.; *Notices*, vol. xx. No. 7.

certain altitudes the crater-form is distinctly and often conspicuously visible, while with higher altitudes the crater formed is entirely lost.

There are one or two points of interest connected with this crater. With altitudes under 25° the crater-form on some occasions has been lost, while on others, with altitudes between 30° and 36° it has been detected. The most remarkable phenomenon is the appearance of *two bright spots* seen at altitudes between 48° and 85°. On the subject of these spots a few remarks may probably be permitted.

These two bright spots were first seen by Mr. Williams on May 4, 1868, 10·30 to 11·30, G.M.T. It does not appear that any one has observed the crater previously at so high a solar altitude as 48°–54°. I also saw the two spots with the Crossley Equatoreal of 7·3 in. aperture on May 6, 1848, exactly as described by Mr. Williams, who observed them with an aperture of $4\frac{1}{16}$ inches, and noticed that there was a dark interval between them of about one-third of the diameter of either, they were about equal in brightness. Mr. Williams has seen them when the Sun was near its meridian altitude.

On Rutherford's Photogram, 1865, March 6, there is east of the spot IV. $A^{a\,17}$, IV. $A^{\zeta\,39}$, a rather indistinct light circle with a somewhat dark interior, the whole very much less bright than IV. $A^{a\,17}$, IV. $A^{\zeta\,39}$. It is possible that the east of the two bright spots may be this which favourable circumstances have rendered more distinctly visible as well as ***brighter***. On Mr. De La Rue's Photogram, 1865, Oct. 4, IV. $A^{a\,17}$, IV. $A^{\zeta\,39}$, is an *elongated* white spot, the elongation is towards the valley IV. $A^{\zeta\,96}$, which agrees with the line joining the two spots seen by Mr. Williams.

The spot IV. $A^{a\,17}$, IV. $A^{\zeta\,39}$, is thus described in the British Association Lunar Catalogue,—

"A bright spot SSW of IV. $A^{a\,7}$, 5''·94, Mag. 0·37, probably a crater on the NE. border of *Hipparchus*." Latitude 5° S.; longitude 2° W.

Note.—IV. $A^{a\,7}$ is *Hipparchus F.* of Beer and Mädler.

Observations of IV. $A^{a\,17}$, IV. $A^{\zeta\,39}$. Latitude 5° S.; Longitude 2° W.

Morning illumination.

No.	Year.	Date, G.M.T.	Authority.	Sun's Alt.	Brightness.	Character.
1	1867	May 11, $8\frac{1}{2}$	Birt	0°– 6°	...°	A shallow crater.
2	1868	Feb. 1, 5–6	Williams	6–12	...	Crater well seen.
3	1868	March 31, $7\frac{1}{2}$	Birt	6–12	...	Crater well defined.

No.	Year.	Date G.M.T.	Authority.	Sun's Alt.	Brightness.	Character.
				° °	°	
4	1868	Jan. 3, 5–6	Williams	12–18	...	Discerned central cone, but not certain.
5	1868	Jan. 3	Baxendell	12–18	...	A well-marked, shallow crater.
6	1867	Nov. 5, 9–10	Williams	18–24	7	Very bright streak of interior shadow on the west.
7	1868	April 1, 5–6	Williams	18–24	4	Whitish patch of light.
8	1867	Dec. 5, 6–8	Williams	24–30	5	Whitish spot; no crater.
9	1868	May 1, 10–11	Williams	24–30	...	Whitish patch; line of interior shadow on the west.
10	1867	Oct. 7, 8½–10	Williams	24–30	...	A very bright spot.
11	1867	Nov. 6, 8–10	Williams	30–36	6	A bright patch of light; streak of shadow scarcely discernible.
12	1868	April 2, 5–6	Williams	30–36	4	Whitish patch of light.
13	1868	April 2, 8½	Birt	30–36	4	A very shallow crater, with interior shadow,
14	1867	Dec. 6, 9–10	Williams	36–42	5	Whitish spot; no crater.
15	1868	May 2, 6½–10	Williams	36–42	...	Long patch of light to the E.
16	1868	May 4, 10½–11½	Williams	48–54	...	*Two* bright spots.
17	1868	May 5, 10½–11½	Williams	60–66	...	*Two* nearly equal and circular bright spots.
18	1868	May 6, 9¾–10½	Birt	72–78	...	*Two* bright spots.
19	1868	May 7, 11½–12	Williams	83–85	...	*Two* bright spots, the east largest.

Evening illumination.

No.	Year.	Date, G.M.T.	Authority.	Sun's Alt.	Brightness.	Character.
20	1867	Nov. 15, 18–20	Williams	36–30	10°	Very bright.
21	1868	Feb. 12, 20½	Williams	30–24	6, 4	Crater very conspicuous, with east peak very bright.
22	1867	Oct. 17, 13–15	Williams	30–24	...	Crater very conspicuous.
23	1867	Oct. 17, 13½	Ingall	30–24	...	Drawn as a crater.
24	1867	Oct. 18, 17–19	Williams	18–12	...	Crater very conspicuous; small central cone casting a shadow.
25	1868	Jan. 15, 20½	Williams	12–6	...	The crater conspicuous, with interior shadow on east fully equal to that of IV. A * 7.

On certain partial Lunar Eclipses not noticed in the Nautical Almanac. By R. A. Proctor, B.A.

When there is a total or partial eclipse of the Moon by the Earth's umbra, the times of first and last contact with the penumbra are recorded in the *Nautical Almanac*. But when the Moon passes wholly or in part within the penumbra without

touching the umbra, no notice is taken of the phenomenon. This seems a defect, for the penumbral passages have now an evident value on account of the application of spectroscopic analysis. Also, there seems something defective in the theory of eclipses, as presented in works on Astronomy, in which, so far as I have seen, no notice whatever is taken of penumbral lunar eclipses. It may readily be shown that when these eclipses are taken into account, the total number of lunar eclipses in any long period slightly exceeds, instead of falling considerably short of, the number of solar eclipses.

It should be noticed that when a solar eclipse occurs alone—that is, without a lunar eclipse at the preceding or following full Moon—the Moon is always penumbrally eclipsed at one of these epochs, and more commonly at both of them. So that, when there are only two eclipses in the year—in which case both are solar—there are frequently *four* penumbral lunar eclipses, and there must be two such phenomena.

In the present year there are only two solar eclipses: one of these was annular and occurred in February, the other is the great total eclipse of August 17th next. The Moon will be penumbrally eclipsed both before and after the great eclipse. The former penumbral eclipse will not be visible in England; the latter I give the elements of this eclipse as deduced from an approximate calculation and projection:

		h	m	s
Greenwich Mean Time of Opposition in R.A. Sept. 1		14	54	0
Moon's Right Ascension		22	45	40·7
		°	′	″
Moon's Declination	S.	9	11	13·7
Sun's Declination	N.	7	52	14·5
Moon's Hourly Motion in R.A.			28	55·5
Sun's Hourly Motion in R.A.			2	15·8
Moon's Hourly Motion in Decl.	N.		8	45·2
Sun's Hourly Motion in Decl.	S.			54·8
Moon's Equatoreal Horizontal Parallax			54	11·4
Sun's Equatoreal Horizontal Parallax				8·9
Moon's True Semi-diameter			14	47·5
Sun's True Semi-diameter			15	53·8

These values, applied in the usual manner to the projection of the eclipse, give the following results:—

	h	m
First Contact with the Penumbra, Sept. 1st	14	16
Middle of the Eclipse	15	43
Last Contact with the Penumbra ..	17	10

Magnitude of the Penumbral Eclipse (Moon's Diameter = 1) 0·33

The first contact with the penumbra occurs at 11° 15′ from the northernmost point of the Moon's limb towards the east.

The last contact at 44° 20′ towards the west.

At the time of central eclipse the penumbra intersects the Moon's limb at points 49° 40′ from the north towards the east, and 83° from the north towards the west. The middle of the shadow lies, therefore, 16° 40′ from the north point towards the west. (In all cases for direct image.)

I take this opportunity of remarking that, during a total lunar eclipse, a portion of the faint light still received from the Moon is probably due to the Sun's corona; and, therefore, the spectroscopic examination of the Moon at such a time might have interesting results. During some total eclipses the Moon has been wholly obliterated from view, even with telescopes having considerable light-gathering power. It might be interesting to inquire how far this peculiarity bears on our views respecting the corona.

I wish also to call the attention of observers of the Sun to the importance of carefully noting the appearance of the solar disk from the 14th to the 20th of August. The observers of the Great Eclipse on the 17th will, doubtless, record the exact positions of the rose-coloured prominences around the Sun's disk; and the comparison of such observations with the recorded positions and motions of solar spots and faculæ may possibly serve to exhibit some such association as has been suspected between the coloured prominences and the solar spots.

Minor Planet, (96) *Œgle.*

The following elements calculated from observations of 17 Feb., at Marseilles, and 1 and 14 March, at Leipzig, by Herr Vogel, are given *Ast. Nach.*, No. 1687.

1868, March 1·5, Berlin M.T.

$$
\begin{aligned}
M &= 346^\circ\ 34'\ 42''\!\cdot\!0 \\
\varpi &= 165\ \ 14\ \ 32\cdot7 \\
\Omega &= 322\ \ 49\ \ 25\cdot9 \\
\iota &= 16\ \ \ 5\ \ 41\cdot7
\end{aligned}
\left.\vphantom{\begin{aligned}M\\ \varpi\\ \Omega\\ \iota\end{aligned}}\right\}\ \text{Mean Equin. } 1868\cdot0.
$$

$$
\begin{aligned}
\phi &= 8\ \ \ 8\ \ 16\cdot8 \\
\log a &= 0\cdot485130 \\
\mu &= 664''\!\cdot\!220.
\end{aligned}
$$

Minor Planet, (97) *Clotho.*

The following elements, calculated by Dr. Maywald from Normal Places of March 1 and 30, and April 28, are given *Ast. Nach.*, No. 1696.

The North German expedition for the observation of the Solar Eclipse of August 18 was to start from Berlin on the evening of Wednesday, July 8. The funds for this expedition are provided by the Norddeutscher Bundesrath, and it is understood that the general superintendence of the expedition rests with a resident Commitee of the Astronomische Gesellschaft. The astronomers will land at Bombay, and will probably take a station considerably to the west of those taken by the British parties. In the selection of station, and in the arrangement of their journeys, they have been assisted by the advice of our best Indian scientific authorities.

The Editor has received from M. Hoek a list of Errata in the paper "On the Phenomena of Meteors:" this will be printed in the next Number.

ERRATUM.

P. 8, line 22, for *Uranus* read *Saturn*.

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// MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. XXVIII. *Supplementary Notice.* No. 9.

The Total Solar Eclipse of August 17–18, 1868.

(*Extract of a Letter from Major J. F. Tennant, R.E. to the Astronomer Royal.*)

Guntoor, August 18, 1868.

"This morning was very promising, and if it had followed the course of its predecessor, we should have had a magnificent clear sky, but it clouded over the east with thin cumulostrati, which, while hardly stopping vision, interfere very much with the photographic energy; and the result was that every negative was under-exposed, and we have little more than very dense marks showing the protuberances. The six plates arranged for were duly exposed, but the heat so concentrated the nitrate-of-silver solution, that, besides showing but faint traces of any corona, they are all covered with spots. Still we may make something of them, and will try.

"Capt. Branfill reports the protuberances unpolarised, and the corona strongly polarised everywhere in a plane passing through the centre of the Sun.

"Complementarily I have to report a continuous spectrum from the corona, and one of bright lines from the prominence I examined. I am, I believe, safe in saying that three of the lines in the spectrum of the protuberances correspond to C, D, and *b*. I saw a line in the green near F, but I had lost so much time in finding the protuberance (owing to the finder having changed its adjustment since last night) that I lost it in the sunlight before measuring it, and I believe I saw traces of a line in the blue near G, but to see them clearly involves a very large change in the focus of the telescope, which was out of the question then.

"I conclude that my result is that the atmosphere of the Sun is mainly of non-luminous (or faintly luminous) gas at a short distance from the limb of the Sun. It may have had faintly

luminous lines, but I had to open the jaws a good deal to get what I could see at first, and, consequently, the lines would be diffused somewhat, still I think I should have seen them. The prominence I examined was a very high narrow one, almost to my eye like a bit of the Sun through a chink in brightness and colour (I could see no tinge of colour), and somewhat zigzagged like a flash of lightning. It must have been three minutes high, for it was on the preceding side of the Sun near the vertex, and was a marked object, both in the last photo-plate just before the Sun reappeared, and to the eye.

"Captain Branfill saw the prominences coloured, as did two other gentlemen, but one in my Observatory (like myself) only saw it white. I should, however, say that for long I never saw *α Orionis* markedly red, nor *Antares*, and I may not catch red soon, though I cannot conceive this being so.

"In conclusion, I may note that the darkness was very slight, and the colour not half so gloomy as in the eclipse of 1857, which was partial at Delhi, where I was then."

On the Cluster in Perseus. By Dr. O. Pihl.

I have the honour of laying before the Society the results of a micrometric examination of the Stellar Cluster in *Perseus*, commonly designated 65 *Bode* or 34 *Messier*, which I have been prosecuting since the year 1860, with a view to obtain, within comparatively small probable errors, a mensuration of all the more conspicuous stars, sufficiently exact to serve as a basis for investigating, at some remote date, the mechanism of the system.

The instrument employed is a Refractor, with 3¼ inch aperture, by H. Krog, of Bergen, equatoreally mounted by Lohmeyer of Hamburg. Owing to the stars under examination, with three or four exceptions, being of a magnitude too low for the employment of a wire-micrometer with illuminated field, and the instrument not being provided with an arrangement for the illumination of the wires upon a dark field, I have been reduced to the exclusive use of bar-micrometers (Boguslawski's), with magnifying powers of 40 and 120, and to a ring-micrometer, with a magnifying power of 40; the latter, however, has been used to a less extent.

All the measurements have been referred to one particular star (No. 25 in the list) on the southern side of the group; the *absolute* position of which, as well as that of the secondary star (No. 33) on the northern side, required for using the Boguslawski micrometer, has been determined by recent observations by Argelander and Fearnley, as also by myself.

From these two fundamental stars a triangulation of the whole group has been performed, principally with the bar-micrometer, and in effecting this I have, for convenience, in addition to the

two above-named stars, employed nineteen others, partly for obtaining the Right Ascension and partly for the Declination. These stars have been examined with special care with reference to the two fundamental stars; and the probable error of their positions in that co-ordinate, for the determination of which for other stars they have been employed, does not generally amount to $0''\cdot25$ of Great Circle.

A number of observations have been taken with the ring-micrometer, mostly with a specific object in view; for instance, the determination of very small differences in Declination. The total number of stars whose positions have been measured is 85; the probable errors in no case amount to $0''\cdot5$ of arc of Great Circle in either co-ordinate; the mean probable error being in R.A. = $0''\cdot298$, and in Decl. $0''\cdot309$. The positions in R.A. and in Decl. have in the majority of cases been obtained by separate observations, the number of which, exclusive of those taken for obtaining the absolute positions, is as follows:—For R.A. 541 sets in all, or 65 on an average for each star; for Decl. 461 sets in all, or 5·5 on an average for each star; but of the latter observations, 418 have been taken with the bar-micrometer, and with that number of sets in either of the two opposite oblique positions of the bar. Each set consists, in the majority of cases, of from six to eight passages across the field.

So large a number of observations was necessary in order to ensure the accuracy required, more especially as the limited size of the instrument and the nature of the micrometers employed are not favourable for obtaining exact results with but few observations.

Having no Meridian Circle at my disposal, I have had to adopt a circuitous and somewhat laborious method for determining the absolute position of the group, and for that purpose resorted to *γ Andromedæ*, the position and proper motion of which have been closely determined by several of the most distinguished of modern astronomers;* this star, at a distance of about 38^m preceding the centre of the group, having a Declination of about $30'$ of arc south of two of the larger stars in the system.

By means of the ring-micrometer (with a mean radius of $1023''\cdot79$) the Declination of these two stars, with reference to *γ Andromedæ*, was found by eleven passages of each. The Right Ascension of three other stars, more favourably situated for that purpose than the two above-named, was determined, on an average, by eight passages of each.

However, being sensible of the numerous chances of error in this mode of determining the position with comparative exactness, I applied to my friend, Professor Fearnley, Director of the Royal Observatory, Christiania, who, by means of the Meridian Circle, kindly obtained the positions of two of the northern, and two of

* Mädler: "Der Fixsternhimmel," p. 23.

the southern, stars, including the two fundamental stars (Nos. 25 and 33), referred to above.

Having noticed in the *Astronomische Beobachtungen* of the Bonn Observatory, that three of the northern stars in the group had been measured by the Meridian Circle of that establishment, among which were the two observed by Professor Fearnley, I wrote to Professor Argelander, who most obligingly furnished me with his positions, as also with the Right Ascension of two other stars. On my own measurements of Right Ascension of the above three stars, by means of γ *Andromedæ*, whose position had been determined with a probable error of $0^s{\cdot}023$, I felt safe in placing a considerable degree of reliance; and as Argelander's and Fearnley's positions, in that co-ordinate, of one of the two stars obtained by both, did not agree very well, whereas my positions, both for this star and for the second measured by those astronomers,—and with regard to which they agree closely,—was not far from the mean of their results ($0^s{\cdot}094$ and $0^s{\cdot}058$ respectively), I have felt justified in using my own results, as well as those of Argelander and Fearnley, for finally determining the absolute Right Ascension.

But in finding the absolute Declination, I have totally rejected my own results, determined by γ *Andromedæ*, which, however, within $2''$ agree with the mean of Argelander and Fearnley's positions: for in this co-ordinate two causes of error are present which cannot be eliminated, viz., the error arising from the error in value of the dimensions of the ring of the micrometer, and the error to be anticipated from the vast difference between the intensity of light in γ *Andromedæ* and of the stars compared with it,—an error which, with so large a difference in Declination, could not be neutralised by measuring the pairs of stars in the upper and lower part of the ring alternately.

By combining Argelander's and Fearnley's results with my own, the ultimate value obtained in Right Ascension varies in four stars from $+0^s{\cdot}219$ to $+0^s{\cdot}328$, and in one (No. 33) the difference is $-0^s{\cdot}011$ from those of Argelander's. It may, however, be observed, that the first four of these stars have been observed by Argelander only on one evening, and upon only one to three wires, whereas the last has been observed on two occasions, and, on one of these, upon seven wires. On the other hand, the above ultimate value varies from $-0^s{\cdot}105$ to $-0^s{\cdot}247$ from Fearnley's Right Ascensions.

By combining the positions in Declination of the four stars measured by Fearnley, and of the two by Argelander, with my own *relative* positions of these stars, the resulting values vary from $+0''{\cdot}50$ to $-1''{\cdot}30$ from Fearnley's, and are $+0''{\cdot}08$ and $2''{\cdot}28$, respectively, at variance with Argelander's positions; the former difference being for the star No. 33, observed by Argelander with the four microscopes, whereas the latter was observed with only one.

The main object of my investigation being to determine the

relative positions of the individual stars, they have all, as previously observed, been referred to a single star (No. 25) in the southern part of the group.

In the following Catalogue the positions with respect to that star are, therefore, given,—in R.A. in seconds of time, and in Decl. in seconds of arc,—but separate columns also contain the absolute positions.

The Probable Error of each position is specified: with regard to R.A. this error is expressed in time, and in an adjacent column reduced to arcs of Great Circle.

In the calculation of the Probable Errors, due reference has been paid to the relative value of each observation entering into the calculation; the formula employed being

$$\text{P. E.} = 0{\cdot}67449\sqrt{\frac{n\,\Sigma\,\Delta^2}{(n-1)\left(\frac{1}{p_1}+\frac{1}{p_1}\cdot\cdot\frac{1}{p^n}\right)\left(p_1+p_2\ldots p_n\right)}},$$

or, for sets with each observation of equal value, the reduced form,

$$\text{P. E.} = 0{\cdot}67449\sqrt{\frac{\Sigma\,\Delta^2}{n\,(n-1)}},$$

n denoting the number of observations, and $p_1\ p_2 \ldots p_{n_2}$ the relative values of the separate observations entering into the calculation.

The constants employed for the calculation of Precession are those of Bessel.

With regard to the magnitude of the stars, I have endeavoured to express them according to Argelander's standard.

The Positions of Bessel in the last column of the Table are reduced from those given in the *Königsberger Beobachtungen*, vol. xvii.: for Zone 529, the corrections given in Cat. II. by Weisse, have been taken into account. It will be observed, that these positions, and specially the positions *inter se* of these seven stars of Bessel's, are, within amounts not altogether slight, at variance with those I have found to exist at the present time. I am aware that it would be premature to conclude from these differences any proper motions of the stars; but, at the same time, the differences are, no doubt, large enough to deserve special notice. In Declination, for instance, Bessel's position for No. 12 differs $-9''{\cdot}67$ from mine; for No. 25 $-2''{\cdot}01$; for No. 60 $+2''{\cdot}41$; for No. 82 $-7''{\cdot}04$, &c. Bessel's difference in Declination between No. 12 and No. 60 is, therefore, upwards of $12''$, and between No. 60 and No. 82, about $9''{\cdot}5$ at variance with mine,—differences which appear somewhat suspicious. They are, undoubtedly, very large, if supposed to arise merely from errors in observation,—considering that Bessel's mean Probable Errors in Declination in his Zone Observations are, so far as I am aware, only about $1''{\cdot}5$, and that the mean Probable Error in my ob-

servations of these stars is only 0″·21. It might be inferred that, as Bessel's Declinations are, in all cases but one,— namely, in that of No. 60, more southerly than those obtained by means of Argelander and Fearnley's Meridian Observations,— the exception, as regards No. 60, may be owing to an error in the reading off of the Declination of that star,— a supposition which the Declination given by Lalande would seem to corroborate. But, on the other hand, it may be remarked that Bessel has measured Nos. 25 and 60 on the same evening, and, consequently, the one immediately after the other, and that yet he has placed No. 60 3″·30 *north* of No. 25; while now it is, according to my measurement, 0″·93, and, according to Fearnley, even 2″·75 *south* of it. Now, if the probable error of a single star in Bessel's Zone Observations is in Decl. = 1″·5, the mean probable error of the above seven stars would be 0″·6. But the mean Declination of Bessel's seven stars is 4″·27 south of the mean Declination now determined. Is it probable that this difference is owing merely to errors in observation, or to errors in the constants, notwithstanding Weisse's revision of Bessel's Tables of Reduction, and to no physical change? Of course this cannot now be answered; but I trust that the examination, the results of which are contained in the preceding Catalogue, may, on some future investigation, be the means of successfully solving the problem, as regards the mutual proper motions of the stars in this extensive system.

On the Plate representing the group, I have, in addition to the stars measured, marked all other stars (117 in number), which, under the most favourable circumstances, can be seen or sighted in my instrument. Their positions have no claim to accuracy beyond that of careful sketches. The 85 stars numbered on the plate have alone been measured and laid down accordingly.

Tulliubjerget, Christiania, June 26, 1868.

No.	Mag.	No. of Obs.	Right Ascension. Mean R.A. 1865·0.	Right Ascension. R.A. refer. to No 25.	Prob. Error. Secs. of Time.	Prob. Error. Secs. of Gt. Circ.	Yearly Precession. 1865·0.	Yearly Precession. Secul. Change.	Declination. No. of Obs.	Declination. Mean Decl. 1865·0.
			h m s		s	″	s	s		° ′ ″
1	10.4	7	2 31 50·286	−62·682	0·041	0·46	3·8172	+0·0396	4	42 13 26·2
2	9.9	6	56·069	56·899	·039	·43	·8181	·0396	4	42 14 36·9
3	10.4	4	59·086	53·882	·027	·30	·8192	·0396	6	42 16 35·7
4	10.1	4	32 10·725	42·243	·018	·20	·8162	·0397	4	42 7 59·2
5	9.8	4	11·886	41·082	·024	·27	·8222	·0398	4	42 21 36·7
6	10.7	5	13·974	38·994	·026	·29	·8158	·0395	4	42 6 39·84
7	8.8	8	19·383	33·585	·020	·23	·8209	·0397	6	42 17 21·12
8	10.3	4	19·813	33·155	·022	·25	·8196	·0396	4	42 14 23·34
9	8.7	9	22·844	30·124	·020	·23	·8221	·0398	5	42 19 25·9
10	9·7	4	24·871	28·097	·015	·17	·8241	·0399	5	42 23 46·1
[illegible]	10.0	5	27·534	25·434	·039	·43	·8161	·0394	4	42 5 5·[illegible]

Mag.	No. of Obs.	Right Ascension. Mean R.A. 1865·0.	Right Ascension. R.A. refer. to No. 25.	Prob. Error. Secs. of Time.	Prob. Error. Secs. of Gt. Circ.	Yearly Precession. 1865·0	Yearly Precession. Secul. Change.	Declination. No. of Obs.	Declination. Mean Decl. 1865·0.
		h m s		s	″	s	s		° ′ ″
8.7	18	2 32 32·123	−20·845	0·014	0·16	3·8168	+0·0394	7	42 5 46·83
10.7	4	34·017	18·951	·018	·20	·8252	·0399	4	42 24 47·47
10.7	6	34·329	18·639	·043	·48	·8248	·0399	4	42 23 52·69
10.5	4	37·448	15·520	·020	·23	·8251	·0399	7	42 23 59·74
9.5	6	38·312	14·656	·032	·36	·8184	·0395	6	42 8 38·24
10.7	4	40·601	12·367	·019	·22	·8258	·0399	6	42 25 4·02
9.3	7	41·075	11·893	·021	·24	·8226	·0397	5	42 17 47·81
10.5	4	41·392	11·576	·018	·21	·8211	·0396	4	42 14 13·07
10.7	5	43·664	9·304	·041	·46	·8254	·0398	4	42 23 43·36
10.4	4	44·106	8·862	·023	·26	·8141	·0392	5	41 57 37·58
9.4	4	44·486	8·482	·016	·18	·8213	·0396	4	42 14 12·17
9.4	4	45·978	6·990	·022	·25	·8220	·0396	4	42 15 41·94
9.9	8	50·211	2·757	·034	·38	·8149	·0392	4	41 58 45·01
8.0	...	52·968	0·000	...	...	·8160	·0393	...	42 0 45·47
9.3	4	59·345	+ 6·377	·027	·30	·8273	·0399	4	42 25 28·01
9.4	6	59·695	6·727	·021	·24	·8240	·0397	7	42 17 55·06
10.0	5	33 0·820	7·852	·042	·47	·8195	·0395	5	42 7 29·99
9.6	4	1·897	8·929	·017	·19	·8213	·0396	5	42 11 29·00
10.2	7	7·743	14·775	·033	·37	·8201	·0395	5	42 8 6·28
8.3	18	8·780	15·812	·015	·17	·8218	·0396	10	42 11 26·20
10.6	4	10·974	18·006	·029	·33	·8243	·0397	5	42 16 48·47
7.8	...	14·345	21·377	...	...	·8284	·0399	...	42 25 36·01
10.1	5	15·326	22·358	·022	·25	·8196	·0394	5	42 5 33·85
8.0	4	16·896	23·928	·013	·15	·8229	·0396	8	42 12 35·76
8.0	20	18·637	25·669	015	·17	·8230	·0396	5	42 12 43·60
10.2	5	19·779	26·811	·038	·42	·8195	·0394	4	42 4 29·36
8.9	6	22·090	29·122	·030	·33	·8221	·0395	5	42 10 7·27
10.4	5	23·773	30·805	·031	·34	·8161	·0392	4	41 56 8·23
9.2	11	25·007	32·039	·029	·32	·8171	·0392	9	41 58 0·42
7.7	10	26·080	33·112	·013	·15	·8213	·0395	13	42 7 39·70
9.8	4	26·755	33·787	·032	·35	·8229	·0395	5	42 11 10·52
8.8	6	30·434	37·466	·023	·26	·8249	·0396	8	42 15 11·04
10.3	5	30·660	37·692	·035	·39	·8228	·0395	4	42 10 25·06
9.3	9	32·355	39·387	·028	·31	·8238	·0396	4	42 12 26·87
8.7	6	33·330	40·362	·030	·33	·8228	·0395	7	42 10 2·33
7.7	12	33·487	40·519	·012	·14	·8216	·0395	12	42 7 11·67
8.3	7	33·590	40·622	·025	·28	·8237	·0396	5	42 11 55·33
10.2	5	33·809	40·841	·024	·27	·8196	·0393	4	42 2 30·64
8.6	4	34·085	41·117	·028	·31	·8260	·0397	6	42 17 12·91
9.3	7	34·181	41·213	·037	·41	·8264	·0397	7	42 17 4·96
10.3	5	36·532	43·564	·043	·48	·8266	·0397	4	42 18 1·07
10.4	6	37·863	44·895	·031	·34	·8193	·0393	4	42 1 19·71

No.	Mag.	No. of Obs.	Right Ascension. Mean R.A. 1865·0	Right Ascension. R.A. refer. to No. 25.	Prob. Error. Secs. of Time.	Prob. Error. Secs. of Gt. Circ.	Yearly Precession. 1865·0	Yearly Precession. Secul. Change.	Declination. No. of Obs.	Declination. Mean Decl. 1865·0.
			h m s		s	"	s	s		° ′ ″
54	8.3	6	2 33 42·248	−49·280	0·028	0·31	3·8237	+0·0395	7	42 10 51·93
55	10·2	5	43·564	50·596	·038	·42	·8197	·0393	4	42 1 16·17
56	8.4	9	47·272	54·304	·019	·22	·8241	·0395	6	42 10 45·66
57	10.2	6	50·397	57·429	·c21	·24	·8202	·0393	5	42 1 19·84
58	9.3	5	50.576	57·608	·025	·28	·8300	·0398	4	42 23 35·67
59	10.3	7	54·887	61·919	·037	·41	·8244	·0395	4	42 10 ·04
60	7.2	11	55·659	62·691	·020	·23	·8203	·0393	18	42 0 44·55
61	9.4	4	56·031	63·063	·023	·26	·8288	·0397	4	42 20 5·37
62	10.2	5	58·912	65·944	·032	·35	·8268	·0396	4	42 15 5·63
63	10.4	6	34 4·415	71·447	·037	·41	·8270	·0396	8	42 14 46·39
64	7.9	12	5·362	72·394	·019	·22	·8270	·0396	8	42 14 31·39
65	10.1	5	5·643	72·675	·030	·33	·8239	·0394	6	42 7 16·80
66	9.9	6	8·012	75·044	·027	·30	·8235	·0394	5	42 6 6·00
67	10.2	6	11·328	78·360	·024	·27	·8211	·0393	5	42 0 11·09
68	10.3	6	11·547	78·579	·035	·39	·8249	·c395	4	42 8 47·03
69	9.5	5	12·381	79·413	·032	·35	·8220	·0393	4	42 2 3·63
70	10.6	4	13·592	80·624	·011	·13	·8208	·0393	6	41 59 10·01
71	10.0	7	15·761	82·793	·035	·39	·8277	·0396	5	42 14 27·08
72	9.9	4	18·916	85·948	·016	·18	·8299	·0397	4	42 19 2·93
73	8.3	20	20·089	87·121	·015	·17	·8331	·0399	12	42 26 0·83
74	10.6	7	30·646	97·678	·031	·34	·8222	·0393	5	41 59 50·82
75	10.6	7	33·387	100·419	·029	·32	·8233	·0393	5	42 0 40·5[illegible]
76	9.8	4	34·478	101·510	·010	·12	·8326	·0398	6	42 22 29·6[illegible]
77	9 8	4	36·242	103·274	·032	·35	·8299	·0396	4	42 16 16·6[illegible]
78	9.6	5	38·466	105·498	·038	·42	·8285	·0395	4	42 12 46·4[illegible]
79	10.4	6	38·823	105·855	·030	·33	·8268	·0394	4	42 8 52·13
80	8.7	7	45·071	112·103	·023	·26	·8285	·0395	6	42 11 46·00
81	10.0	5	50·147	117·179	·036	·40	·8295	·0395	5	42 13 8·90
82	8.4	12	52·256	119·288	·c25	·28	·8250	·0393	9	42 2 40·22
83	10.0	7	35 1·011	128·043	·036	·40	·8295	·0395	4	42 11 29·25
84	10.7	4	5·836	132·868	·027	·30	·8300	·0395	4	42 11 58·55
85	10.3	6	2 35 19·026	−146·058	0·039	0·43	3·8314	+0·0395	4	42 12 48·52

No.	Decl. refer. to No. 25.	Prob. Error.	Yearly Precession. 1865·0.	Yearly Precession. Secul. Change.	Positions found by other Observers reduced to 1865·0. Mean R.A.	Positions found by other Observers reduced to 1865·0. Mean Decl.
	"	"	"	"	h m s	° ′ ″
1	+ 760·73	0·24	15·811	−0·350		
2	+ 831·43	·31	·806	·350		
3	+ 950·29	·46	·803	·350		
4	+ 433·81	·44	·793	·351		
5	+ 1251·25	·21	·792	·351		
6	+ 354·37	·41	·790	·351		

No.	Decl. refer. to No 25.	Prob. Error.	Yearly Precession. 1865·0	Yearly Precession. Secul. Change.	Positions found by other Observers reduced to 1865·0. Mean R.A.	Mean Decl.	
	"	"	"	"	h m s	° ′ ″	
7	+ 995·65	0·13	15·785	−0·351	2 32 19·109	..	Argelander 1860·9
8	+ 817·87	·34	·784	·351			
9	+ 1120·51	·21	·782	·351	2 32 22·571	42 19 23·70	Argelander 1850·9
10	+ 1380·71	·42	·779	·351			
11	+ 259·62	·17	·777	·351			
12	+ 301·36	·30	·774	·351	2 32 32·076	42 5 37·16	Bessel 1831·9
13	+ 1442·00	·39	·772	·351			
14	+ 1387·22	·09	·771	·352			
15	+ 1394·27	·42	·769	·352			
16	+ 472·77	·36	·767	·352			
17	+ 1458·55	·41	·766	·352			
18	+ 1022·34	·24	·765	·352	2 32 40·856	...	Argelander 1860·9
19	+ 807·60	·26	·765	·352			
20	+ 1377·89	·43	·763	·352			
21	− 187·89	·48	·762	·352			
22*	+ 806·70	·29	·762	·352			
23	+ 896·47	·22	·761	·352			
24	− 120·46	·35	·757	·352			
25	0·00	...	·754	·352	2 32 53·044	42 0 43·46	Bessel 1831·9
					2 32 53·215	42 0 46·77	Fearnley 1865·1
26	+ 1482·54	·39	·749	·352			
27	+ 1029·59	·36	·748	·352			
28	+ 404·52	·22	·747	·352			
29	+ 643·53	·34	·746	·352			
30	+ 440·81	·33	·741	·353			
31	+ 640·73	·23	·740	·353			
32	+ 963·00	·31	·738	·353			
33	+ 1490·54	...	·735	·353	2 33 14·356	42 25 35·93	Arg. 1860·9 & 1861·1
					2 33 14·450	42 25 36·40	Fearnley 1865·1
34	+ 288·38	·30	·734	·353			
35	+ 710·29	·28	·732	·353	2 33 17·070	42 12 30·98	Bessel 1831·9
36	+ 718·13	·32	·731	·353	2 33 18·358	42 12 38·44	Bessel 1831·9
37	+ 223·89	·20	·729	·353			
38	+ 561·80	·28	·728	·353			
39	− 277·24	·40	·727	·353			
40	− 165·05	·17	·725	·353			
41	+ 414·23	·18	·724	·353	2 33 26·236	42 7 36·10	Bessel 1831·9
42	+ 625·05	·34	·724	·353			
43	+ 865·57	·28	·721	·353			
44	+ 579·59	·45	·720	·354			
45	+ 701·40	·29	·719	·354			
46	+ 556·86	·31	·718	·354			
47	+ 386·20	·17	·718	·354			
48	+ 669·86	·21	·718	·354			

No.	Decl. refer. to No. 25	Prob. Error.	Yearly Precession. 1865·0.	Yearly Precession. Secul. Change.	Positions found by other Observers reduced to 18 Mean R.A.	Mean Decl.	
	"	"	"	"	h m s	° ' "	
49	+ 105·17	0·18	15·717	−0·354			
50	+ 987·44	·40	·717	·354			
51	+ 1039·49	·38	·717	·354			
52	+ 1035·60	·41	·715	·354			
53	+ 34·24	·41	·714	·354			
54	+ 606·46	·34	·711	·354			
55	+ 30·70	·45	·708	·354			
56	+ 600·19	·24	·705	·354			
57	+ 34·37	·20	·703	·354			
58	+ 1370·20	·19	·702	·354			
59	+ 562·57	·35	·698	·354	2 33 55·136	42 0 43·89	Lalande 1790?
60	− 0·92	·10	·698	·354	2 33 56·066	42 0 46·96	Bessel 1831·9
61	+ 1159·90	·18	·697	·354	2 33 55·860	42 0 44·05	Fearnley 1865·
62	+ 860·16	·44	·695	·355			
63	+ 840·92	·40	·690	·355			
64	+ 825·92	·20	·689	·355	2 34 3·600	42 14 29·69	Lalande 1790?
65	+ 391·33	·47	·688	·355			
66	+ 320·53	·30	·687	·355			
67	− 34·38	·27	·683	·355			
68	+ 481·56	·37	·683	·355			
69	+ 78·16	·21	·683	·355			
70	− 95·46	·47	·681	·355			
71	+ 821·61	·26	·679	·355			
72	+ 1097·46	·38	·677	·356	2 34 19·761	(42 25 57·43) computed	Argelander 18
73	+ 1515·36	·16	·675	·356	2 34 20·230	42 26 1·20	Fearnley 1865·
74	− 54·65	·43	·666	·356			
75	+ 55·08	·41	·663	·356			
76	+ 1304·16	·46	·662	·356			
77	+ 931·20	·19	·661	·356			
78	+ 720·93	·15	·659	·356			
79	+ 486·66	·45	·658	·356			
80	+ 660·53	·29	·653	·356			
81	+ 743·43	·20	·648	·357			
82	+ 114·75	·24	·646	·357	2 34 52·444	42 2 33·18	Bessel 1831·9
83	+ 643·78	·45	·638	·357			
84	+ 673·08	·42	·634	·357			
85	+ 723·05	0·27	15·622	−0·358			

A Rediscussion of the Observations of the Transit of Venus, 1769. By E. J. Stone, Esq.

Several methods of great refinement have been applied, within the last few years, to the determination of the fundamental unit of length of the Solar System,—the mean distance of the Sun from the Earth, or its equivalent, the mean horizontal equatorial parallax of the Sun. These investigations have all pointed to values about $8''\cdot90$. Each method appears to have its own inherent difficulty, but it is inconceivable that the systematic errors of each of these methods should tend to unduly increase the resulting value of the solar parallax. In opposition to the value $8''\cdot90$ we have that of $8''\cdot58$ deduced by Encke from the transits of *Venus* of 1761 and 1769. A transit of *Venus* has been considered, and I think justly considered, the most favourable of all our opportunities for the accurate determination of the solar parallax.

The observations made in 1769 were made, under generally favourable circumstances, by observers of experience. The places of observation were undoubtedly chosen with skill and judgment. The results have been discussed by an astronomer of acknowledged skill and ability. The discordance of the value thus deduced, by more than $0''\cdot3$ from the mean of the values determined, by at least three other independent methods, each entitled to great confidence, has naturally given rise to much anxiety and some doubt. It appeared to me that a new discussion of the observations made in 1769 must necessarily lead, if to nothing else, to a clearer view of the sources of systematic error, or wrong interpretation, which might be feared, and ought to be guarded against, in the observations proposed to be made at the Transits of 1874 and 1882.

I believe that my investigation has led me to the detection of several grave and fundamental errors, which have previously been made in the discussion of these results, and to a value of the solar parallax entitled to be received with confidence. From P. Hell's *Reise nach Wardoe bei Lappland und seine Beobachtung des Venus-Durchganges im Jahre* 1769, by Carl Ludwig Littrow. Wien, 1835, I extract the following:

Ingress.

"Internus autem limborum Solis et Veneris contactus Sole sat clare lucente, attamen aliquantulum limbo Solis et Veneris undulantibus observatus a me Tubo Dolondiano Haffniensi.

	H	M	S
Videtur contactus fieri	9	32	35
Contactus certus Visus		32	41
Fulmen		32	48

Pater Sajnovics suo tubo

Contactus dubius	9	32	30	30
Certissimus ut ajebat	9	32	45	45

Idem obtinuit D. Borgrewing secunda nempe — 10″—post numerata minuta, sed loco 32 minutorum mihi exhibuit 33′.

Egress.

Ego tubo meo ad idem Horologium

	H	M	S
Videtur aliqua gutta nigra intra limbum Solis et Veneris ante contactum formari ..	15	26	6
gutta hæc minui videtur valde		26	12
Disparet. et contactum fieri censeo		26	17
Certissimus contactus		26	19

Pater Sajnovics.

Contactus dubius certus	15	26	18
Certus			26
D. Borgrewing	15	26	10

Some alterations and additions to the Journal made in darker ink, are indicated by bolder writing. They appear to be chiefly in the order of arrangement and explanation. Fulmen 32 48, appears alone in the darker ink.

It will be seen that at the egress Father Hell makes a distinction between the forming of the black drop and the contact. It has been previously assumed that at the ingress "contactus certus visus," refers to the breaking of the black drop, although we have the phrase, "Disparet, et contactum fieri censeo," &c., referring to the actual contact of the limbs at the egress. This false interpretation is at the very root of the discussion, and an error here leads to nothing but confusion. I shall assume, and I think there will be no further doubt upon this point, that the same phrases must be similarly interpreted at the ingress and egress. Therefore, taking the means of "dubius certus" and "certus" as the true time of contact, I have

Ingress.

	Contact of Limbs. h m s	Reduction to true M.T. m s
Hell's observation	9 32 38	− 1 1·8
Sajnovics'	9 32 37·5	− 1 1·8

Hence, in Paris Mean Time, we have,

	h m s
Hell's observations	9 31 36·2
Sajnovics'	9 31 35·7

I believe it probable that the minutes given by Borgrewing are right, and that he really tried to observe the breaking of the black drop. This, however, is doubtful, and I shall not use the observation.

Egress.

	Contact of Limbs.	Correction to M.T.
	h m s	s
Hell's observation	15 26 18·0	− 59·6
Sajnovics'	15 26 22·0	− 59·6
D. Borgrewing	15 26 10	

Or, in Paris Mean Time,

	h m s
Hell's observation	15 25 18·4
Sajnovics'	15 25 22·4

Since Borgrewing's corresponding observation at ingress is lost, I shall not use his observation at egress. Its use would not, however, change my result. I adopt, therefore, the following observed durations from internal contact to internal contact at Wardhus:—

	h m s
From Hell's observations	5 53 42·2
From Sajnovics'	5 53 46·7

I would also call attention to Father Hell's difference at egress between the formation of the black drop and contact of the limbs, viz. 12ˢ.

Kola.

The observations at this station were made under unfavourable circumstances. I shall adopt the same data as Encke. The phase is that from the breaking to the formation of the black drop. Encke places the observations in the second class. I shall give it a weight one-half that of the other observations. It is, however, very exactly represented by my result.

Observations at Hudson's Bay by W. Wales and Dymond. Extracted from the *Phil. Trans.* 1769.

	Apparent Time.	
	h m s	
Exterior contact at the ingress	0 57 0·6	J.D.
	0 57 7·6	W.W.
Interior ditto	1 15 21·3	W.W.
	1 15 25·3	J.D.
The thread of light broke at the internal contact	7 0 45·5	W.W.
	7 0 48·5	J.D.
External contact	7 19 1·25 *	W.W.
	7 19 20·25 *	J.D.

* Very hazy, and the limbs badly defined.

Remarks.

(3) The heavens at the beginning, and for a considerable time, both before and after, were frequently obscured by clouds, but, in the intervals, the air was very clear, and the Sun's limbs extremely well defined.

(4) Soon after *Venus* was half immerged, a bright crescent, or rim of light, encompassed all that part of her circumference which was off the Sun, thereby rendering her whole periphery visible. This continued very bright until within a few minutes of the internal contact, and then vanished away gradually.

(5) We took for the instant of the first internal contact the time when the least visible thread of light appeared behind the subsequent limb of *Venus*, but before that time *Venus'* limb seemed within that of the Sun, and his limb appeared behind hers in two very oblique points, seeming as if they would run together in a broad stream, like two drops of oil, but which, nevertheless, did not happen, but joined in a very fine thread, at some distance from the exterior limb of *Venus*. This appearance was much more considerable at the egress than at the ingress, owing, as we apprehend, to the bad state of the air at the time. We took for the instant of internal contact, at the egress, the time when the thread of light disappeared before the preceding limb of the planet, from which time W.W. took notice that he had told about 24^s when the limbs of the Sun and *Venus* were apparently in contact; a circumstance which he did not venture to attend to at the egress.

(6) Nothing like an atmosphere (except the above-mentioned phenomena); no satellite observed.

(7) The haziness at egress arose from the usual state of the atmosphere, 10° or 12° above the horizon.

The observations of Wales and Dymond refer to the time of the breaking and formation of the black drop. Wales estimates the interval between the forming of the black drop at egress and the contact of the limbs at 24^s. These observations are clearly not comparable with those made at Wardhus, except allowance be made for the difference of phase observed.

St. Joseph.

The observers at and near this station were Chappe, Pauly, Vicente Doz, and Salvador Medina. I cannot find any details of the observations of Vicente Doz and Salvador Medina, but their results agree so closely with those of Chappe that the observations evidently refer to the same phases of the phenomena.

Extract from "*Voyage en Californe pour l'Observation du Passage de Vénus sur le disque du Soleil, le* 3 *Juin*, 1769. Par M. Chappe." Paris, 1772.

	Temps observé à la pendule.	Temps Vrai.
	h ′ ″	h ′ ″ ‴
2 Juin	23 57 32	23 59 17 2

à la lunette achromatique de 3 pieds.

"*Note.*—J' apperçois *Vénus* faisant une petite échancrure sur le bord du Soleil parfaitement terminé. Je ne crois pas que cette

Première phase s'écarte beaucoup de la véritable, parceque l'échancrure étoit très petite.

		h ′ ″
3 Juin	0 3 30	0 5 15·0

"Entrée du centre, estimée. Je fus très attentif à examiner si je verrois *Vénus* hors du Soleil, avec le croissant qui a été vu dans le passage de 1761 ; mais je ne l'apperçus pas. Je remarquai seulement que vers le milieu de l'entrée de cette planète on distinguoit une partie du disque de *Vénus* proche du disque du Soleil, tel qu'on le voit dans la figure première, planche troisième. Les deux corners, A et B, ou continuation du disque de *Vénus*; sembloient à la vérité annoncer le commencement du croissant que je n'aurai peut-être pas apperçu à cause que ma lunette groississoit beaucoup et étoit par conséquent, moins claire.

Observé.	Temps Vrai.	
h ′ ″	h ′ ″ ‴	
0 15 42	0 17 26 $52\frac{1}{2}$	Second contact.

"A l'entrée totale de *Vénus* j'observai très distinctement le second phénomène qui avoit été remarqué par la plus grande partie des astronomes en 1761. Le bord du disque de *Vénus* s'alongea (voy. figure 2). Comme s'il étoit attiré par le bord du Soleil. Je n'observai point pour l'instant de l'entrée totale,

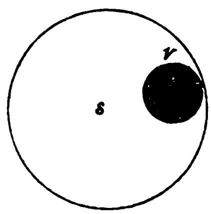


Fig. 2.

celui où le bord de *Vénus* commençoit à s'alonger; mais ne pouvant pas douter que ce point noir ne fît partie du corps opaque de *Vénus*, j'observai le moment où il étoit à sa fin; de façon que l'entrée totale ne peut être arrivée plutôt, mais peut-être plus tard de deux ou trois secondes. Le point noir étoit un peu moins obscur que le reste de *Vénus*. Je crois que c'est le même phénomène que celui que j'observai à Tobolsk en 1761.

Temps observé à la pendule.	Temps Vrai.
h ′ ″	h ′ ″ ‴
5 53 9	5 54 50 $8\frac{2}{3}$

Premier contact à la sortie, *avec la lunette de dix pieds* (not the same telescope). Le Soleil étoit ondoyant ainsi que *Vénus*, ce qui rendoit cette observation très difficile. A ce premier contact

Venus s'est alongée plus considérablement que le matin, en s'approchant tout-à-coup du bord du Soleil.

$6^{h}\ 2'\ 16''$ $\qquad$ $6^{h}\ 3'\ 57''\ 12'''\tfrac{1}{2}$

Sortie du centre estimée très exactement à ce qu'il m'a paru.

$6^{h}\ 11'\ 38''$ $\qquad$ $6^{h}\ 13'\ 19''\ 7'''\tfrac{1}{2}$

Second contact ou sortie totale. Elle ne me paroît pas être arrivée plutôt peut-être 4ˢ plus tard, mais je n'en suis pas certain.

"Pour observer avec toute la précision possible les deux contacts à la sortie, je disposai ma lunette de façon que je ne fusse pas obligé de la remuer vers ces moments. Sans cette précaution j'eusse été dans le cas de perdre de vue *Vénus;* de prendre le fond du ciel pour le bord du disque de cette planète, et de commettre ainsi une erreur énorme, au lieu qu'en ne quittant pas un instant de vue, au dernier contact, le bord de *Vénus* que paroissoit un peu plus noir que le fond du ciel, j'eus cette phase avec toute l'exactitude possible.

"J'avois chargé M. Pauly d'observer à la lunette de trois pieds les deux contacts de la sortie; il étoit déja un peu exercé au observations. Il observa le premier contact 22ˢ plutôt que moi et le dernier 37ˢ plutôt. Comme il étoit à côté de moi, je m'apperçus du moment où il quitta la lunette pour aller à la pendule et je vis très bien qu'il fixoit trop tôt les moments du premier et du second contact, car je voyois encore *Vénus* parfaitement lorsqu'il étoit à la pendule."

It is clear from Chappe's account that at the ingress he observed the breaking of the black drop. I have given the figure 2 for comparison with corresponding figures at Otaheite.

I consider, from the description given by Chappe himself, that at the egress he did not catch the formation of the black drop. He appears to have been surprised by the contact being established all at once. This view is materially strengthened by the observation of Pauly, who gives a contact 22ˢ earlier than that of Chappe. This observation of Pauly is clearly an observation of the formation of the black drop.

Observations made at King George's Island, in the South Sea, by Mr. Charles Green, formerly assistant at the Royal Observatory, Greenwich, and Lieut. James Cook, of H.M.S. *Endeavour. Phil. Trans.* 1771.

The telescopes employed in making the observations were, two reflecting telescopes of two feet focus each, made by the late Mr. James Short.

Transit of *Venus* by Mr. Green; magnifying power, 140.

	App. time. h m s
First internal contact of ♀'s limb and the ☉, see fig. 4, (June 2)	21 43 15
Penumbra and ☉'s limb in contact, see fig. 5	21 43 55
First contact of penumbra. undulating, but the thread of light visible and invisible alternately (June 3)	3 14 3
Second internal contact of the bodies	3 14 51

Fig. 5.

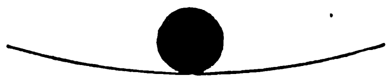


Fig. 4.

Observations of Cook; magnifying power, 140.

First internal contact, or the limb of ♀ seemed to coincide with the ☉'s, fig. 2	21 43 15
A small thread of light seen below the penumbra, fig. 3	21 44 15
Second internal contact of the penumbra, or the thread of light wholly broken..	3 14 13
Second internal contact of the bodies, and appeared as in the first	3 14 45

Fig. 3.

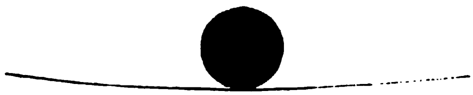


Fig. 2.

Dr. Solander's observations.

	h m s
Ingress, light seen glimmering under ♀	21 43 28
♀'s free from the ☉'s limb	21 44 2
♀'s true limb out	3 31 49
♀'s atmosphere out	3 32 13

I shall not use Solander's observations. He has not observed the internal contact or breaking of black drop at egress: the time at ingress 21 44·2 falls between the two observations of Green and Cook, and its introduction would not therefore modify sensibly my result. There appears here a real difficulty in exactly understanding the phenomena observed by Green and Cook. I append Cook's remarks upon these observations.

"The first appearance of *Venus* on the Sun, was certainly only a penumbra, and the contact of the limbs did not happen till several seconds after, and then it appeared as in figure 4 (not given); this appearance was observed both by Mr. Green and me; but the time it happened was not noted by either of us: it appeared to be very difficult to judge precisely of the times that the internal contacts of the body of *Venus* happened, by reason of the *darkness of the penumbra at the Sun's limb, it being there nearly, if not quite, as dark as the planet.* At this time a faint light, much weaker than the rest of the penumbra, appeared to converge towards the point of contact, but did not quite reach it, see fig. 2. This was seen by myself and the two other observers, and was of great assistance to us in judging of the time of the internal contacts of the dark body of *Venus* with the Sun's limb. Fig. 5 (not given) is a representation of the appearance of *Venus* at the middle of the egress and ingress, for the very same phenomenon was observed at both: at the total ingress, the thread of light made its appearance with an uncertainty of several seconds; I judged that the penumbra was in contact with the Sun's limb 10″ sooner than the time set down above; in like manner at the egress the thread of light was not broke off or diminished at once, but gradually, with the same uncertainty: the time noted was when the thread of light was wholly broke by the penumbra."

It appears to me clear that the penumbra, *as dark or nearly as dark as the planet,* is nothing more nor less than a part of the planet itself. If this be so, Cook and Green have both observed contacts, and not the forming and breaking of the black drop. Cook states that at the egress he observed the time when the thread of light was wholly broken off by the penumbra.

I shall assume in my investigation that internal contacts were observed.

It now remains to form the equations of condition. $d\alpha$, $d\Delta$ denote the relative Tabular errors of *Venus* and the *Sun* in R.A. and N.P.D. $d\pi$ the correction required to the assumed value of solar parallax 8″·49, ϱ, ϱ' the corrections required by Encke's assumed semidiameter of *Venus* corresponding respectively to an internal contact and the formation or breaking of the black drop.

$$x = 6{\cdot}57\, d\alpha + 24{\cdot}45\, d\Delta + 39{\cdot}71\, \varrho$$
$$y = 6{\cdot}57\, d\alpha + 24{\cdot}45\, d\Delta + 39{\cdot}71\, \varrho'$$

Then $\frac{x-y}{2}$ = interval between the internal contact and breaking or forming of the black drop.

Wardhus.

The observations made use are of the internal contacts observed by Hell and Sajnovics.

Ingress.

Observer.	
Hell	$10{\cdot}237\, d\alpha - 16{\cdot}236\, d\Delta - 44{\cdot}50\, d\varpi - 19{\cdot}658\, \varrho = - 34^s{\cdot}8$
Sajnovics	$10{\cdot}237\, d\alpha - 16{\cdot}236\, d\Delta - 44{\cdot}50\, d\varpi - 19{\cdot}658\, \varrho = - 35^s{\cdot}3$

Egress.

Observer.	
Hell	$16{\cdot}538\, d\alpha + 8{\cdot}135\, d\Delta + 30{\cdot}84\, d\varpi + 19{\cdot}658\, \varrho = + 18^s{\cdot}6$
Sajnovics	$16{\cdot}538\, d\alpha + 8{\cdot}135\, d\Delta + 30{\cdot}84\, d\varpi + 19{\cdot}658\, \varrho = + 22^s{\cdot}6$

For the durations we have sensibly

		Observer.
(1)	$x + 75{\cdot}34\, d\varpi = + 53{\cdot}4$	Hell.
(2)	$x + 75{\cdot}34\, d\varpi = + 57{\cdot}9$	Sajnovics.

Hell's observation at egress gives 12^s between the formation of the drop and internal contact.

Kola.

The observation here is from the breaking to the formation of the drop. The weight given to this equation will only be one half.

(3)	$y + 76{\cdot}63\, d\varpi = + 21{\cdot}6$	Rumovsky.

Hudson's Bay.

The observations here are from the breaking to the formation of the black drop.

(4)	$y + 23{\cdot}59\, d\varpi = + 0{\cdot}5$	Wales.
(5)	$y + 23{\cdot}59\, d\varpi = - 0{\cdot}5$	Dymond.

St. Joseph.

The observations here are mixed.

Ingress.

Observer.						
Chappe	$10{\cdot}03\, d\alpha$	$- 16{\cdot}78\, d\Delta$	$- 2{\cdot}01\, d\varpi$	$- 19{\cdot}941\, \varrho'$		$= + 3{\cdot}6$
V. Doz	,,	,,	,,	,,	,,	$= + 1{\cdot}8$
Medina	,,	,,	,,	,,	,,	$= + 6{\cdot}8$

Egress.

Observer.						
Chappe	$16{\cdot}64\, d\alpha$	$+ 8{\cdot}78\, d\Delta$	$- 33{\cdot}31\, d\varpi$	$+ 19{\cdot}941\, \varrho$		$= - 2{\cdot}3$
V. Doz	,,	,,	,,	,,	,,	$= - 5{\cdot}0$
Medina	,,	,,	,,	,,	,,	$= - 5{\cdot}0$

For durations we have—

		Observer.
(6)	$\frac{x+y}{2} - 31{\cdot}30\, d\pi = -\ \ 5{\cdot}9$	Chappe.
(7)	$\frac{x+y}{2} - 31{\cdot}30\, d\pi = -\ \ 6{\cdot}8$	V. Doz.
(8)	$\frac{x+y}{2} - 31{\cdot}30\, d\pi = -\ 11{\cdot}8$	Medina.

Pauly at this station observed the formation of the black drop 22^s before Chappe observed the internal contact.

Otaheite.

The observations here are from internal contact to internal contact.

		Observer.
(9)	$x - 83{\cdot}40\, d\pi = -\ \ 5{\cdot}9$	Green.
(10)	$x - 83{\cdot}40\, d\pi = -\ 15{\cdot}9$	Cook.

Multiplying all the equations except the Kola equation by 2, and reducing the 10 equations by the method of least squares, I find the following equations for the determination of x, y, and $d\,\Pi$.

$$19x + 3y - 252{\cdot}28\, d\pi = +\ 309{\cdot}0$$
$$3x + 12y + 48{\cdot}10\, d\pi = -\ 27{\cdot}4$$
$$-\ 252{\cdot}28\, x + 48{\cdot}10\, y + 123133{\cdot}75\, d\pi = 45536{\cdot}46$$

$$\therefore \quad 119113\, d\pi = 50220{\cdot}58$$
$$d\pi = 0''{\cdot}421$$
$$\text{or} \quad \pi = 8''{\cdot}91 \pm 0{\cdot}008\,\iota$$
$$x = 23^s{\cdot}4$$
$$y = -\ 9{\cdot}8$$
$$\frac{x-y}{2} = 16^s{\cdot}6$$

ι is the probable error of a single observation of contact.

If $\iota = 3^s$ the probable error of π is $0''{\cdot}02$.

The mean of the three results, 24^s, 22^s, 12^s, for the difference between the internal contact and breaking of the black drop is 19^s. The value of $\frac{x-y}{2}$ resulting from the equations of condition is therefore satisfactory.

It will be seen from the following table that the observed durations are all represented in a satisfactory manner.

I may here mention that the satisfactory solution of these equations in the way which has previously been virtually attempted by assuming $x = y$ is impossible. Of course by reject-

ing the observations at different stations, different results could be thus obtained, and any required value of the parallax within wide limits thus obtained.

The discordances between the computed and observed durations are reduced as follows,—

Observer.	s		s		Mean Error. s
Hell	53·4	to	− 1·7	Wardhus.	+ 0·6
Sajnovics	57·9	to	+ 2·8		
Wales	+0·5	to	+ 0·4	Hudson's Bay	− 0·1
Dymond	−0·5	to	− 0·6		
	+21·6	to	−0·9	Kola.	− 0·9
Chappe	−5·9	to	+0·5	St. Joseph.	− 1·6
V. Doz	−6·8	to	−0·4		
Medina	−11·8	to	−5·4		
Green	−5·9	to	+ 5·8	Otaheite.	+ 0·8
Cook	−15·9	to	−4·2		

I consider therefore that, by simply interpreting strictly the language employed by the observers, I have been led to a solution which satisfies the whole of the ten observed durations, and gives at the same time, from the equations of condition, a satisfactory result for the difference between the time of internal contact and the breaking of the black drop. The value of deduced solar parallax 8″·91 appears to me therefore entitled to great weight. It is in most satisfactory agreement with the values which have lately been otherwise obtained. I do not consider the incomplete observations of ingress, and particularly of egress, sufficiently numerous and well distributed to afford, by their combination with the observations here made use of, satisfactory determinations of $d\,\alpha\; d\,\Delta\; \varrho\; \varrho'$, and to give, at the same time, a value of $d\,\Pi$ entitled to more, or even to equal confidence to that obtained from the durations. A great number of these observations were made under unfavourable circumstances, and the errors of observation as shown by their discordances are large. In addition to the mere errors of observation, we have, in the discussion of these imperfect observations, the full errors of assumed longitudes coming into the equations of conditions, and also errors of judgment in selecting the phase of the phenomenon of the transit of *Venus* really attempted to be caught by the observer.

I shall merely state, in conclusion, that I have not alluded to Powalky's discussion, because I consider that far too great license has been allowed the judgment in the selection of the materials to be used. Several of the results well represented in my equations are rejected as erroneous by him. If the necessity of separating the phenomena observed, in the way I have done, be admitted, no reliance can of course be placed upon any result

obtained without such separation. The data are, in fact, inconsistent, and nothing but confusion could result from the mere application of least squares.

Blackheath, 1868, *Sept.* 23.

On the Variability of η Argûs. By J. Tebbutt, Jun. Esq.

In the *R. A. S. Monthly Notices* for January 1866, was published a series of comparisons of η *Argûs*, made by me with neighbouring stars from 1854 to the middle of March 1865. A marked diminution of the star's light has taken place since that period, it being at present hardly distinguishable to the naked eye, even by oblique vision. I now forward a series of careful comparisons made since March 1865.

Comparisons.

1866, Feb. 16. Sky brilliantly clear. η *Argûs* was considerably less than B.A.C. 3655 or 3688.

1866, March 22. Sky very clear in the neighbourhood of η *Argûs*. Less than B.A.C. 3655 or 3688.

1866, June 29, 6^h 15^m P.M. Sky very clear, but η *Argûs* hardly distinguishable. Much less than B.A.C. 3655 or 3688.

1866, July 4, 6^h 45^m P.M. Sky beautifully clear, and the *Via Lactea* very distinct. η *Argûs* was much less than B.A.C. 3655 or 3688, and even less than B.A.C. 3642. It could be distinguished only by oblique vision; B.A.C. 3680 and 3673 could not be distinguished at all with the naked eye.

1866, Dec. 3, 10^h 20^m P.M. Scarcely distinguishable, and was very much less than B.A.C. 3655 or 3688.

1866, Dec. 8. Midnight. Sky beautifully clear, and the stars at a great altitude. η *Argûs* was very much less than B.A.C. 3655 or 3688. It was seen as a distinct stellar point in the nebula by oblique vision. It might be considered about equal, or perhaps superior, to B.A.C. 3642, the latter being seen by oblique vision.

All the foregoing comparisons were made with the naked eye.

1866, Dec. 11, 11^h P.M. By means of a small telescope, η *Argûs* was estimated to be brighter than B.A.C. 3673, and perhaps slightly inferior to B.A.C. 3642 or 3680.

The following comparisons, except those on May 4, 1867, and April 13 and 22, 1868, were made with a telescope of 3½ inches aperture, and a magnifying power of about 30.

1866, Dec. 12, 11^h P.M. B.A.C. 3655, a light orange-coloured star, was considerably the brightest in the field of the telescope; is had a very small companion on the north side. B.A.C. 3642 and 3680 were the next in order of brightness, and

appeared to be about equal; B.A.C. 3648 next; then η *Argûs*, which about equal to B.A.C. 3657. B.A.C. 3673 was less than η *Argûs*. The magnitude of η *Argûs* by a very careful examination was intermediate between those of B.A.C. 3648 and 3673, and about equidistant between B.A.C. 3673 and 3680. The stars and nebula were beautifully distinct. There are no stars in the catalogued positions of B.A.C. 3679 and 3683.

1867, Jan. 12. Of η *Argûs*, B.A.C. 3655, 3680, and 3673, B.A.C. 3655 was much the brightest; η *Argûs* and 3680 were nearly equal; but 3680 decidedly the brighter, and 3673 the least of all. The comparisons were made between 9^h 30^m and 9^h 45^m P.M.; the stars being beautifully distinct; but the Moon about five days old in the west.

1867, Jan. 26, 8^h 20^m P.M. Beautifully clear night, and the Moon absent. Of the stars mentioned in the comparisons for Jan. 12, B.A.C. 3655 was the brightest, and η *Argûs* was greater than B.A.C. 3673 and less than B.A.C. 3680.

1867, March 2, 9^h 15^m P.M. Of the stars B.A.C. 3655, 3680, 3673, and η *Argûs*, the first was the brightest, η *Argûs* ranging between B.A.C. 3680 and 3673, but approximately to B.A.C. 3680. The night was beautifully clear, the Moon absent, and the stars at a great altitude.

1867, April 17, 6^h 40^m P.M. Clear sky, but Moon near the opposition. η *Argûs* was considerably brighter than B.A.C. 3673 and slightly inferior to B.A.C. 3680.

1867, May 4. B.A.C. 3680 less than B.A.C. 3655, and η *Argûs* less than B.A.C. 3680, and greater than B.A.C. 3673. The comparisons were made while the stars were crossing the field of the transit telescope.

1867, July 27, 9^h 25^m P.M. Beautifully clear sky, and the nebula about η *Argûs* very distinct. Of the stars B.A.C. 3655, 3680, η *Argûs*, and B.A.C. 3673, 3655 was the brightest; 3680 next; η *Argûs* next; and 3673 the least. The magnitude of η *Argûs* was nearer that of 3680 than that of 3673.

1867, Dec. 28. Sky beautifully clear. Of the compared stars, B.A.C. 3655 was by far the brightest; B.A.C. 3680 the next; η *Argûs* the next; and B.A.C. 3673 the least. The inferiority of η *Argûs* to B.A.C. 3680 was marked; but it was not much superior to B.A.C. 3673.

1867, Dec. 31. Of the compared stars, B.A.C. 3655 was the brightest, and η *Argûs* was certainly less than B.A.C. 3680, and somewhat greater than B.A.C. 3673. The comparisons were made about half an hour after midnight, the stars being at a great altitude.

1868, Feb. 26, 7^h 45^m P.M. Sky beautifully clear, and the Moon just set. Of the compared stars, B.A.C. 3655 was the brightest; η *Argûs* ranged between B.A.C. 3680 and 3673, but approximated to 3680.

1868, Feb. 27, 8^h 45^m P.M. Sky cloudless, and the nebula very distinct. η *Argûs* was compared with B.A.C. 3655, 3673,

and 3680. B. A. C. 3655 was the brightest of the four. η *Argûs* was greater than 3673, and less than 3680.

1868, April 13. B. A. C. 3642, 3655, 3673, 3680, and η *Argûs* were compared as they crossed the field of the transit telescope, both with and without illumination; the power employed being 25. The last four stars were compared at one view, B.A.C. 3642 having shortly before quitted the field. 3642 was not so bright as 3655. 3655 was much brighter than 3680. 3680 considerably brighter than η *Argûs*, and η *Argûs* slightly superior to 3673. The superiority of B. A. C. 3680 to η *Argûs* was very marked.

1868, April 22. The following comparisons were made in the field of the transit telescope, both with and without illumination. Of the compared stars, B. A. C. 3655 was by far the brightest. η *Argûs* was greater than B. A. C. 3673 and less than B. A. C. 3680. The inferiority of η *Argûs* to 3680, and its superiority to 3673, were marked.

It is obvious from these observations that η *Argûs*, during 1867 and the elapsed portion of the present year, has not exceeded the *sixth* magnitude. It does not appear, therefore, that the present variations of this star are reconcileable with the theory of Professor Wolf, in the *Monthly Notices* for May 1863, and the *Ast. Nach.* No. 1420, which gives 1861 and 3·6 respectively, as the time and magnitude for the minimum.

Windsor, New South Wales, April 29th, 1868.

Observations of a Minor Planet discovered by Prof. C.J. Watson at Ann Arbor Observatory, 1868, July 11.

	Ann Arbor M.T.	R.A.	Decl.
	h m s	h m s	° ′ ″
1868, July 11	13 36 14·7	21 10 54·40	−15 47 45·4
	15 16 47·9	21 10 52·28	−15 48 4·3
13	12 2 19·9	21 9 53·43	−15 57 24·9

The planet resembles a star of the 11th magnitude.

This planet appears to be the same as that independently discovered by M. Coggia on July 16. E. J. S.

The Astronomische Gesellschaft.

Two biennial meetings have been held of the Astronomische Gesellschaft, the first at Leipzic, from August 31 to September 2, 1865, the second at Bonn, from August 22 to 24, 1867, both under the Presidency of Prof. Argelander. Among the subjects discussed at the meeting of 1867 are—

1. The Construction of New Tables of *Jupiter*. It appeared from communications received from MM. Hansen and Leverrier that both of these Astronomers were in fact occupied with the question, and thus that no action of the Society was requisite.

2. A new reduction of the older observations of the Periodic Comets had been in discussion at the Leipzic meeting. Four points had been specified—the new determination of the places of the stars of comparison, the calculation of the auxiliary quantities with the now-received values of the constants for the times of the appearance of the comets, the calculation of solar ephemerides for these times, lastly, the publication of the originals of the older comet observations.

As to the first point, Prof. Argelander had, in all the necessary cases, redetermined at the Bonn Observatory the places of the stars of comparison as collected by Prof. Schönfeld, and had published the new places in the sixth volume of the Bonn Observations.

As to the second point, it was hoped that the New Tables of Bessel's Auxiliary Quantities for the whole period 1750 to 1839, in continuation of the "Tabulæ Pulcovenses," beginning in 1840, would be published: this, however, was not undertaken by the Society, partly in consequence of it being known that some portions of the work had been accomplished or were in progress in America.

As to the third point, nothing has been done.

As to the fourth, some progress had been made by Prof. Argelander, who however mentioned that, for instance, the originals of the important observations of Triesnecker were not to be found, and that those of Olbers were not so perfect as to allow of a complete fresh reduction; it would be necessary in many cases to rest contented with the distances of comet and star as determined by Olbers himself.

Prof. Argelander remarked that he had been equally unsuccessful in discovering the original observations of Variable stars; those, for instance, of Pigott, Goodricke, and Koch, seemed to be quite lost.

It appeared that the calculations for the comets of Encke, Faye, Brorsen, D'Arrest, and Tuttle, were being proceeded with; but a list of thirty-one comets from 1830 to 1867 was given, which remained for further discussion. And a wish was expressed that Astronomers who were occupying themselves with any particular comets, or appearances thereof, would put themselves in communication with the Society.

M. von Struve expressed the like wish as to information being given to him at Pulkova in regard to any discussions of Double stars.

3. The need of a new reduction of Bradley's observations had been noticed as well at the foundation of the Society at Heidelberg, as at the Leipzic meeting. This however was not so much the concern of the Society as of the Pulkova Observatory, which

had received from Greenwich a carefully-compared copy of the Observation-Journals from 1750 to 1765, and of the other Bradley manuscripts; the work, in consequence of the illness of Dr. Winnecke, had been undertaken by Dr. Auwers.

4. A scheme by Prof. Schönfeld for the nomenclature of Variable stars was discussed.

5. A programme was received for the observation of all the stars up to the ninth magnitude between -2° and $+80^\circ$ declination. The co-operation of Astronomers was invited; the Observatories which had offered to take part in the work were Berlin, Bonn, Helsingfors, Leipzig, Mannheim, and (after the completion of some work in hand) Leyden.

6. A discussion took place, and some resolutions were adopted, as to the nomenclature of Comets and Minor Planets.

The next meeting was appointed to be at Vienna in the year 1869.

Besides the *Vierteljahrsschrift*, or Quarterly Journal of the Society, the following works have been published by them:—

I. Hülfstafeln zur Berechnung specieller Störungen, enthaltend die rechtwinkligen Ecliptical-Coordinaten und die von Orte des gestörten Körpers unabhängigen Theile der Störenden Kräfte für die Planeten Venus, Erde, Mars, Jupiter, Saturn, Uranus, und Neptun, von 1830–1864. 1865.

II. Lesser, Dr. Otto. Tafeln der Metis mit Berücksichtigung der Störungen durch Jupiter und Saturn. 1865.

III. Weiler, Dr. A. Ueber das Problem der drei Körper im Allgemeinen und ins Besondere in seiner Anwendung auf die Theorie des Mondes.

IV. Hoüel, Dr. G. J. Tables pour la reduction du temps en parties décimales du jour. 1866.

V. Auwers, Arth. Reduction der Beobachtungen der Fundamental-Sterne am Passage-instrument der Sternwarte zu Palermo in den Jahren, 1803–1805, und Bestimmung der mittleren Recht-Ascensionen für 1805. 1866.

VI. Rechtwinkelige und Polar co-ordinaten des Jupiter (nach Bouvard's Tafeln) sowie Componenten der störenden Kräfte mit denen Jupiter auf die Sonne wirkt von 1770–1836. 1866.

VII. Auwers, Arth. Untersuchungen über veränderliche Eigenbewegungen. Zweiter Theil. Bestimmung der Elemente der Siriusbahn.

VIII. Schjellerup, genäherte Oerter der Fixsterne von welchen in den Astronomischen Nachrichten Band 1-66 selbstständige Beobachtungen angeführt sind, für die Epoche 1855 hergeleitet und nach den geraden Aufsteigungen geordnet. 1867.

Recent Publications.

Descriptive Astronomy, by George F. Chambers, F.R.A.S. Oxford, Clarendon Press, 1867, 8vo, pp. ix. to xxxvii. and 1 to 816.

The work appears to answer in a high degree to the author's idea of making it at once attractive to the general reader, serviceable to the student, and handy for the purposes of reference to the professional Astronomer. The arrangement of the subject is in the ten books:—The Sun and Planets, Eclipses and their Associated Phenomena, Physical and Miscellaneous Astronomical Phenomena, Comets, Chronological Astronomy, the Starry Heavens, Practical Astronomy, Sketch of the History of Astronomy, Meteoric Astronomy, and Astronomical Tables. Great pains appear to have been used in the collection and selection of the information, and in bringing it up to the latest period; and at the same time that the whole is in a very readable form, the facts are very frequently presented, as is obviously most convenient, in a tabular form: for instance, the history of particular discoveries or researches is given (often very completely) in the natural place in connexion with the celestial object to which they refer, but the short book of 21 pages, "Sketch of the History of Astronomy," is in fact a chronological table of Astronomers, occurrences, and discoveries. A valuable chapter on Celestial Photography and a Catalogue of Binary Stars are contributed to the work by Mr. A. Brothers. There are in all 224 illustrations; as to those of Clusters and Nebulæ, the author remarks that they are not at all to his satisfaction, there being the usual difficulty of preventing the undue exaggeration of the brilliancy of the stellar details.

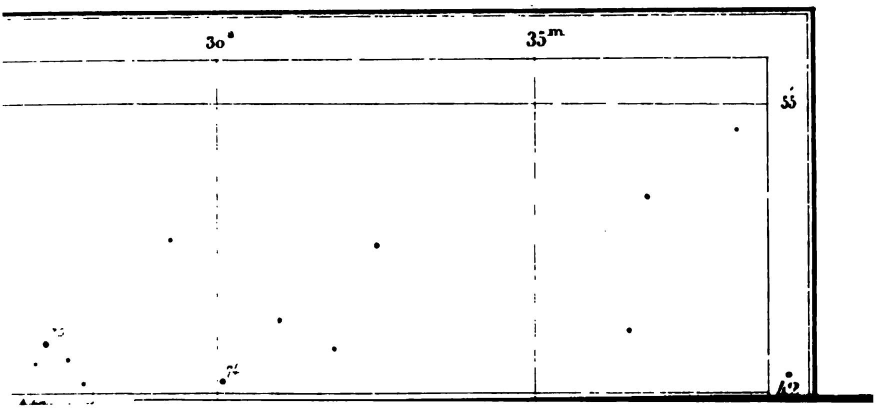
Theoretical Astronomy, relating to the Motions of the Heavenly Bodies revolving around the Sun, in accordance with the Law of Universal Gravitation, embracing a Systematic derivation of the Formulæ for the Calculation of the Geocentric and Heliocentric places, for the determination of the Orbits of Planets and Comets, for the Correction of approximate elements, and for the computation of Special Perturbations; together with the theory of the combination of Observations and the method of Least Squares. By James C. Watson, Director of the Observatory at Ann Arbor, and Professor of Astronomy in the University of Michigan. London: Trübner and Co.

The somewhat long title of this remarkable and laborious work gives a general idea of its contents. The book commences with the fundamental principles of dynamics and treats systematically all the problems presented; the author hoping in this way

to aid the progress of the Science by attracting into th
and educating competent computers. Numerical exampl
given, derived from actual observations and the tables
accompany the work are of great value.

M. Hoek has communicated to the Editor the following Errata in the paper on "The Phenomena of Meteors."

Page	Line	
132	10	W *should be* W_1.
132	last line	$\sqrt{A^2+s}$, *should be* $\sqrt{A^2+s^2}$.
133	3	$e = 0$ *should be* $e = 1$.
134	12	$x_2 = \mp\sqrt{A(1+\cos B)}$, *should be* $x_2 = \mp\sqrt{\frac{1}{2}A(1-$
136	4	$\frac{p+x}{g}$ *should be* $\frac{p+x}{y}$.
136	7	$\frac{dy}{\sin\frac{1}{2}n}$ *should be* $\frac{dq}{\sin\frac{1}{2}n}$.
137	14	$R = 1$ *should be* $r = 1$.
138	table of values of D 27° 7′ *should be* 27·7.	
139	1	V *should be* U.
142	second form (40) $2\cos\frac{1}{2}\cos H$ *should be* $2\cos\frac{1}{2}n\cos H$.	
142	20	$U = B_1$ *should be* $U = B$.
143	Table Sept. 4 *should be* Sept. 5.	
143	last line 0·00879 *should be* 0·000879.	
144	4	angular *should be* relative.
144	9	point R_1 *should be* point R.
148	20	observed *s* *should be* adopted *s*.
148	25	$\frac{g}{V^2} = 0{\cdot}3809$ *should be* 0·4217.
148	29	31° 15′ *should be* 31° 51′.



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RECEIVED DURING THE SESSION OF 1867–68,

AND OF

BOOKS PURCHASED WITH THE TURNOR FUND

DURING THE SAME PERIOD,

FORMING

APPENDIX XIX.

To the Catalogue of the Library of the Royal Astronomical Society.

Abbott, Francis, Results of Twenty-five Years' Meteorological Observations for Hobart Town, together with a two Years' Register of the principal Atmospheric Meteors and Auroræ Australes, 4to. *Hobart Town*, 1866	The Author.
Academy of Sciences of the Institute of France, Comptes Rendus Hebdomadaires, t. lxiv., pt. 9, to t. lxvi., pt. 20, 4to. *Paris*, 1867	The Academy
Airy, G. B., on Sound and Atmospherical Vibrations, with the Mathematical Elements of Music, 8vo. *London and Cambridge*, 1868	The Author.
American Academy of Arts and Sciences, Proceedings, vol. vii., Nos. 13 to 23, 8vo. *Boston and Camb. U.S.* 1866	The Academy
American Ephemeris and Nautical Almanac for 1869, 8vo. *Washington*, 1867	The American Government
American Philosophical Society, Proceedings, No. 76, 8vo. *Philadelphia*, 1866	The Society.

The Amsterdam Academy.	Amsterdam, Jaarboek van de Kon. Akademie te Amsterdam, 1866, 8vo. *Amsterdam*, 1866
——	———— Processen Verbaal van de gewone Vergaderingen, 1866–7, 8vo. *Amsterdam*, 1866–7
The Author.	Anonymous, The Theories of Copernicus and Ptolemy, by a Wrangler, 8vo. *London*, 1867
——	———— La Question Pascal-Newton, Soupçons d'un Bouquiniste, 8vo. *Paris*, 1867
——	Auwers, A., Bestimmung des Parallaxe des Sterns 34 Groombridge, 4to. *Berlin*, 1867
Mr. J. Williams.	Baker, Thos., The Geometrical Key, or the Gate of Equations unlocked, 4to. *London*, 1684
The Author.	Bakewell, F. C., A Dynamical Theory of the Figure of the Earth, proving the Poles to be elongated, 8vo. *London*, 1867
The Society at Batavia.	Batavia, Naturkundig Tijdschrift, vol. xxix., 8vo. *Batavia*, 1866
The Berlin Academy.	Berlin, Abhandlungen der k. Akad. der Wissenschaften aus dem Jahre 1866, 4to. *Berlin*, 1867
——	——— Monatsbericht, 1867, 8vo. *Berlin*, 1867
Royal Observatory, Berlin.	——— Astronomisches Jahrbuch, 1870, 8vo. *Berlin*, 1867
Observatory at Bern.	Bern, Meteorologische Beobachtungen, 1866. *Bern*, 1866
The Institute at Bologna.	Bologna, Memorie della Accademia delle Scienze dell' Instituto di, 4to. *Bologna*, 1865–6
——	——— Rendiconto di, 1864, 1867, 8vo. *Bologna, v. y.*
H. M. Government.	Bombay, Magnetical and Meteorological Observations in 1864, 4to. *Bombay*, 1867
The Boston Library.	Boston, U. S., Index to the Catalogue of Books in the Bates Hall of the Public Library, 1st Supplement, 8vo. *Boston, U. S.* 1866
The Author.	Brayley, E. W., The Periodical Meteors of November, 12mo. *London*, 1867
The British Association.	British Association, Report of the Thirty-sixth Meeting held at Nottingham, August 1866, 8vo. *London*, 1867

Brothers, A., Catalogue of Binary Stars, 8vo.	*London*, 1867	The Author
Bruhns, Dr. C., Resultate aus den Meteorologischen Beobachtungen angestellt an mehreren orten im Konigreich Sachsen in den Jahren 1760 bis 1865 und an den Zwei-und-zwansig Konig. Sachsischen Stationen im Jahr 1865, 4to.	*Leipsig*, 1867	——
Brussels, Annales de Observatoire Roy., tome xvii., 4to.	*Bruxelles*, 1868	Royal Observatory, Brussels.
——— Annuaire, 1868, 12mo.	*Bruxelles*, 1866	——
——— Mémoires de l'Académie Royale de Belgique, tome xxxvi., 4to.	*Bruxelles*, 1867	L'Acad. Roy. de Belgique.
——— Bulletins, t. 22–24, 8vo.	*Bruxelles*, 1866–7	——
——— Tables Générales du Recueil des Bulletins, 8vo.	*Bruxelles*, 1867	——
——— Annuaire, 1867–68, 12mo.	*Bruxelles*, 1867	——
——— Mémoires Couronnées publiés par l'Acad. Royale de Belgique, tome xxxiii., 1865, 1867, 4to.	*Bruxelles*, 1867	
——— Mémoires Couronnés, t. xix.–xx., 8vo.	*Bruxelles*, 1867–8	——
Cambridge Philosophical Society, Transactions, vol. x., pt. 2, vol. xi., pt. 1, 4to.	*Cambridge*, 1868	The Society.
Chambers, G. F., Weather Facts and Predictions, 8vo.	*London*, 1868	The Author.
Cherbourg, Mémoires de la Soc. Imp. de, tomes xi.–xii., 8vo.	*Paris*, 1865–66	The Society.
Christiania, Det Konglige Norske Fredericks Universitats Aarsberetnung for Aaret 1866, 8vo.	*Christiania*, 1867	——
——— Meteorologiske Jagttageleser, 1863–6, paa Christiania Observatorium, ob. folio	*Christiania*, 1867	——
——— ——— paa fem Telegrafstationer vid Norges Kyst Forste og andes Aargung, ob. folio	*Christiania*, 1867	——

Observatory at Coimbra.	Coimbra, Ephemerides Astronomicas Calculadas para o Meridiana do Observatorio da Universidade para 1867–1869, large 8vo. *Coimbra, v. y.*
——	——— Posiçao Geographica do Observatorio da Coimbra, 8vo. *Coimbra,* 1867
The Collegio Romano.	Collegio Romano, Bulletino Meteorologico v. n., folio *Roma,* 1867–8
Le Bureau des Longitudes.	Connaissance des Temps pour 1868, 8vo. *Paris,* 1867
The Academy.	Connecticut Academy of Arts and Sciences, Transactions, vol. i., pt. 1, 8vo. *Newhaven, U. S.* 1866
The Society at Copenhagen.	Copenhagen, Det Konglige Danskei Vdenskabarnes Selskabs Skrifter, Femte Rœkke Sjette Bind, 8vo. *Kjobenhavn,* 1867
——	——— Oversigt over det Kongelige Danske Videnskabernes Selskabs forhandlingar 1865–7, 8vo. *Kjobenhavn,* 1865–7
The Editor.	Cosmos, from June 26, 1867, to June 6, 1868, 8vo. *Paris,* 1867–8
The Author.	D'Arrest, H., Siderum Nebulosorum Observationes Havnienses, 4to. *Hauniæ,* 1867
Dépôt Gén. de la Marine.	Dépot Gén. de la Marine, Annales Hydrographiques, 8 tomes, 8vo. *Paris,* 1867
——	——— Annuaire des Marées, 12mo. *Paris,* 1866–7
——	——— Pilote du Golfe d'Aden, 8vo. *Paris,* 1866
——	——— Pilote du Golfe Persique, 2 parts, 8vo. *Paris,* 1866
——	——— Routier de l'Ile Jersey, 8vo. *Paris,* 1866
——	——— Routier de l'Australie, vol. iii., 8vo. *Paris,* 1866
——	——— Routier des Côtes sud d'Afrique, 8vo. *Paris,* 1866

Dépot Gén. de la Marine, Mer. de Chine, iii^{me} partie, Instructions Nautiques sur les Iles, &c. entre les Phillippines et le Japon, &c., 8vo. *Paris*, 1867 — Dépôt Gén. la Marine.

——————— Mer de Chine, v^{me} partie, La Mer du Japon, 8vo. *Paris*, 1867 — ———

——————— Seconde Supplement sur la Mer de Chine, 8vo. *Paris*, 1867 — ———

——————— Considerations Générales sur la Mer Méditerranée, 8vo. *Paris*, 1866 — ———

——————— Instructions Nautiques sur la Nouvelle Caledonie, 8vo. *Paris*, 1867 — ———

——————— Note sur les Traversées de Retour du Golfe de Mexique en France, 8vo. *Paris*, 1866 — ———

——————— Renseignmentes Nautiques sur quelques ports de l'Oceanie, &c., 8vo. *Paris*, 1866 — ———

——————— Catalogue Chronologique des Cartes, Plans, &c., qui composent l'Hydrographie Française, 8vo. *Paris*, 1866 — ———

Dijon, Mémoires de l'Académie Imp. de, 1864–5, 8vo. *Dijon*, 1865–6 — The Dijon Academy.

Edinburgh Royal Society, Transactions, vol. xxiv., part iii., 4to. *Edinburgh*, 1867 — The Society

——————— Proceedings, 1867, 8vo. *Edinburgh*, 1867 — ———

Engellmann, Dr. R., Resultate aus Doppelstern-Messungen, 4to. *Leipsig*, 1867 — The Author

Fuss, V., Untersuchungen uber die Bahn des Doppelsterns Σ 3062 *St. Petersbourg*, 1867 — ———

Geneva, Mémoires de la Société de Physique et d'Histoire Naturelle, tome xix., 1re partie, 4to. *Genève*, 1867 — The Society

Geographical Society, the Royal, Journal, vol. xxxvi. *London*, 1867 — Royal Geographical Society

——————— Proceedings, vol. xi., Nos. 3–4, 8vo. *London*, 1867–8 — ———

The Society at Gottingen.	Gottingen, Abhandlungen der K. Gesselschaft der Wissenschaften. Dreizehnter Band, 1866–67, 4to. *Gottingen*, 1868
——	———— Nachrichten, 1867, 12mo. *Gottingen*, 1867
The Author.	Gould, B. A. Biographical Notice of J. M. Gilliss, 8vo. *Cambridge, U. S.*, 1867
The Luminous Meteor Committee.	Greg, R. P., and A. J. Herschel, Atlas of Charts of the Meteor Tracks contained in the British Association Catalogue of Observations of Luminous Meteors, extending over the years from 1845 to 1866, Atlas *London*, 1867
The Authors.	Guldberg, M., and Waage, P., Etudes sur les Affinités Chimiques, 4to. *Christiania*, 1867
The Author.	Hansen, P. A., Tafeln der Egeria, 8vo. *Leipsig*, 1867
——	———— Von der Methode der Kleinsten quadrate im Allgemeinen und in ihrer Anwendung auf die Geodasie, 8vo. *Leipsig*, 1867
——	Harrison, J. P., on the Relation of Insolation of Atmospheric Humidity, 8vo. *London*, 1867
The Observatory.	Harvard College, Annals of the Astronomical Observatory of, vol. ii. part 2, vol. v. 4to. *Cambridge, U.S.* 1867
The Author.	Heis, Dr. E., Sammlung von fünf Sterncharten . . . zum Einzeichnen der Sternschnuppen de November periode, 4to. *Köln*, 1868
Prof. Plantamour.	Hirsch, A., et Plantamour, E., Nivellement de précision de la Suisse exécuté par la Commission géodésique fédérale, 4to. *Genève*, 1867
The Author.	Hoek, M., Determination de la Vitesse avec laquelle est entrainée une onde lumineuse traversant un milieu en mouvement. Sur les Prismes Achromatiques construits avec une seule substance, 8vo. *Amsterdam*, 1867
——	Hope, Beresford, Speech on Moving the Rejection of the Metric Weights and Measures Bill, 8vo. *London*, 1868
——	Huggins, W., on the Results of Spectrum Analysis applied to the Heavenly Bodies, 8vo. *London*, 1868

Hull Literary and Philosophical Society, Annual Report, 1866–67, 8vo. *Kingston-upon Hull*, 1867 — The Society.

Hunyady, E. de, Sur une espèce particulière des surfaces et de courbes algébraiques et sur les propriétés générales des courbes du quatrième ordre, 4to. *Paris*, 1867 — The Author.

Jerwood, James, on the Longitude of Places and on the Application of the Electric Telegraph to determine it, 8vo. 1867 — ———

Jordan, W. L., a Treatise on the Action of Vis Inertiæ in the Ocean, 8vo. *London*, 1868 — ———

Journals. Asiatic Society, The Royal, Journal, N.S. vol. iii. part 1, 8vo. *London*, 1867 — The Society.

——— Assurance Magazine, Nos. 68 to 71, 8vo. *London*, 1867–68 — The Institute of Actuaries.

——— The Astronomical Register, Nos. 55 to 66, 8vo. *London*, 1867–68 — S. Gorton, Esq.

——— Astronomische Nachrichten, Nos. 1643 to 1697, 4to. *Altona*, 1867–68 — Dr. Peters.

——— The Athenæum Journal, Nos. 2068 to 2119, 4to. *London*, 1867–68 — The Editor.

——— American Journal of Science and Art, Nos. 130 to 135, 8vo. *Newhaven* (*U. S.*), 1867 — The Editors.

——— The Canadian Journal, No. 66, 8vo. *Toronto*, 1868 — The Canadian Institute.

——— Dublin Royal Society, Journal, No. 36, 8vo. *Dublin*, 1867 — The Society.

——— Franklin Institute, Journal, No. 498 to 508, 8vo. *Philadelphia*, 1867 — The Institute.

——— Geological Society, Quarterly Journal, Nos. 91 to 94, 8vo. *London*, 1867–68 — The Geological Society.

——— Herapath's Railway Journal, Nos. 1462 to 1513, 4to. *London*, 1867–68 — J. Herapath, Esq.

——— The Horological Journal, Nos. 107 to 118, 8vo. *London*, 1867–68 — The Horological Institute.

The Editor.	Journals. The Intellectual Observer, Nos. 66 to 72, 8vo. *London*, 1867
———	——— The London Review, Nos. 364 to 414, folio. *London*, 1867–68
———	——— Le Moniteur Scientifique, Nos. 252 to 268, 8vo. *Paris*, 1867
Dr. Francis.	——— The Philosophical Magazine, Nos. 227 to 239, 8vo. *London*, 1867–68
The Photographic Society.	——— The Photographic Journal, Nos. 181 to 192, 8vo. *London*, 1867–68
The Editor.	——— The Quarterly Journal of Science, Nos. 15 to 18, 8vo. *London*, 1867–68
The Society of Arts.	——— Society of Arts, Journal, Nos. 760 to 811, 8vo. *London*, 1867–68
The Society.	——— Royal Scottish Society of Arts, Journal, vol. vii. part 3, 8vo. *Edinburgh*, 1867
The Editor.	——— The Student and Intellectual Observer, Nos. 1 to 5, 8vo. *London*, 1868
The Institution.	——— United Service Institution, The Royal, Journal, Nos. 44 to 48, 8vo. *London*, 1867–68
The Author.	Julius, F. H., Berekening van de Loopbaan der Komeet 1863–66, 8vo. *Utrecht*, 1867
The Society.	Lancashire, Historic Society of, Transactions, U.S., vol. vi.–vii. 8vo. *Liverpool*, 1866–67
———	Leeds, Annual Report of the Philosophical and Literary Society of, 8vo. *Leeds*, 1867
The Society at Leipsig.	Leipsig, Berichte uber die Verhandlingen der K. S. Gesellschaft der Wissenschaften, 1867, 1, 2, 4, 5, 8vo. *Leipsig*, 1867
The Society.	——— Astronomical Society, Vierteljahrsschrift der Astronomischen Gesselschaft, parts 1, 2, 3, 4, for 1866, 2, 3, 4, 1867, 8vo. *Leipsig*, 1866–67

Leipsig Astronomical Society, Publications by:— The Soci

1. Hulfstafeln zur Berechnung specieller Störungen enthaltend der rechtwinkligen Ekliptical-coordinaten und die vom orte des gestörten Korpers unabhangigen theile der Storenden Krafte fur die Planeten Venus, Erde, Jupiter, Saturn, Uranus, und Neptune, von 1830, bis 1864, 4to. *Leipsig*, 1865
2. Tafeln der Metis mit Berucksichtigung der Störungen durch Jupiter und Saturn, von D. Otto Lesser, 4to. *Leipsig*, 1865 ——
3. Uber das Problem der drei Körper im Allgemeinen und ins Besondere in seiner Anwendung auf die Theorie des Mondes, von Dr. A. Weiler, 4to. *Leipsig*, 1866 ——
4. Tables pour la Réduction du Temps en parties décimales du Jour, par G. J. Houel, 4to. *Leipsig*, 1866 ——
5. Reduction der Beobachtungen der Fundamental Sterne am Passageinstrument der Sternwarte zu Palermo in den Jahren 1803, bis 1805, von A. Auwers, 4to. *Leipsig*, 1866 ——
6. Rechtwinkelige und Polar-coordinaten des Jupiter (nach Bouvards Tafeln) sowie componenten der storenden Kräfte mit denen Jupiter auf die Sonne wirkt von 1770 bis 1830, 4to *Leipsig*, 1866 ——
7. Untersuchungen über veränderliche Eigenbewegungen von G. F. J. A. Auwers, Zweiter Theil, Bestimmung der Elemente der Sirius-bahn, 4to. *Leipsig*, 1868 ——
8. Genäherte Oerter der Fixsterne von welchen in den Astronomische Nachrichten, Band 1, bis 66, selbstandige Beobachtungen angeführt sind fur die Epoche 1855 hergeleitet und nach den geraden Aufsteigungen geordnet von H. C. F. C. Schjellerup, 4to. *Leipsig*, 1867 ——

Lespiault, M., Théorie géométrique de la Variation des Eléments des Planètes, 4to. *Paris*, 1868 The Auth

Littrow, C. von, Sternschnuppen und Kometen, 8vo. *Wien*, 1867 ——

The Author.	Littrow, K. von, Bemerkungen zu nachstehender Abhandlung des Herrn Dr. Astrand "Neue einfache Mittel fur Zeit-und-langenbestimmungen," 8vo. *Wien*, 1867
——	Littrow, C. de, Suggestions for Mariners about the Use and the Exactness of the Methods of Determining the Longitude, and the Variation of the Compass by Circum-meridian Altitudes, 8vo. *Vienna*, 1868
The Lombardic Institute.	Lombardy. Memorie del Reale Instituto Lombardo, vol. x. fasc. 3, 4to. *Milano*, 1866
——	———— Rendiconti del Reale Instituto, 1865–66, 8vo. *Milano*, 1866
The Author.	Loomis, Elias, a Treatise on Astronomy, 8vo. *New York*, 1866
The Royal Observatory, Madrid.	Madrid, Annuario del Real Observatorio, 1868, 8vo. *Madrid*, 1867
The Author.	Maestri, Dr. P., Rapport soumis à la Junte Organistrice sur le programme de la VIme Session du Congrès international de Statistique, 8vo. *London*, 1867
——	Mailly, L'Espagne Scientifique, 12mo. *Bruxelles*, 1868
The Council of the City of Manchester.	Manchester. 15th Annual Report on the Working of the Free Public Libraries, 1866–67, 8vo. *Manchester*, 1867
H.M. Government in Victoria.	Melbourne Observatory, Results of the Astronomical Observations at the, 1863, 1864, and 1865, 8vo. *Melbourne*, 1866
The Society.	Meteorological Society, Proceedings, Nos. 32 to 37, 8vo. *London*, 1867–68
The Author.	Molison, A. R., Against the Theory of the Retarding Influence of Tidal Action on the Axial Motion of the Earth, and showing the True Force of Tidal Energy, 8vo. *n. p. n. d.*
The Carlo Alberto Reale Collegio.	Moncalieri, Bulletino Meteorologico del Osservatorio del R. Collegio Carlo Alberto in Moncalieri con Correspondenza del Osservatorio del Seminario di Alessandria, vols. 1, 2, and 3, parts 1, 2, 3, folio. *Torino*, 1866–68
[illegible]	Munich. Abhandlungen der K. B. Akademie du Wissenschaften Zehnten Bandes Erste Abtheilung, 4to. *Munchen*, 1866

Munich. Sitzungsberichte, 1867, 4to. *Munich*, 1867 — The Munich Academy.

—— Annalen der K. Sternwarte bei Munchen, xv., xvi. band, 8vo. *Munchen*, 1867 — The Royal Observatory, Munich.

Newcomb, Simon, Description of the Transit Circle of the U. S. Naval Observatory, with an Investigation of its Constants, 4to. *Washington*, 1867 — The Author.

—— Investigation of the distance of the Sun and of the Elements which depend upon it from the observations of Mars, during the opposition of 1862, and from other sources, 4to. *Washington*, 1867 — ——

New South Wales, Transactions of the Philosophical Society of, 8vo. *Sydney*, 1866 — The Society.

Naples, Società Reale, Rendiconto, 1865, 1866, 1867, fol. *Napoli*, *v. y.* — The Royal Society at Naples.

The Nautical Almanac for 1871, 8vo. *London*, 1867 — The Lords Comm. of the Admiralty.

Palermo, Bulletino Meteorologico del R. Osservatorio, tomo iii. No. 6, 7, 8, 9, 10. — The Royal Observatory of Palermo.

—— Osservazioni Meteorologiche, nell' anno 1864, 4to. *Palermo*, 1865

—— Giornale di Scienze Naturali ed Economiche del consiglio di perfizionamento annesso al t. Instituto Tecnico, vol. ii. fasc. 2, 3, 4; iii. fasc. 1, 2, 3, 4to. *Palermo*, 1866 — The Royal Institute at Palermo.

Paris, Annales de l' Observatoire Imp. de Paris, Observations, t. xxi., xxii., 4to. *Paris*, 1866, 67 — M. Le Verrier.

—— Atlas Météorologique, année 1866, atlas. *Paris*, 1867 — ——

—— Atlas des Mouvements généraux de l' atmosphère, année 1864, Juin, Décembre, rédigée par Obs. Imp. Atlas. *Paris*, 1868 — ——

—— Atlas des Orages de l' année 1865, rédigée par l' Observatoire Impérial, atlas. *Paris*, 1866 — L' Association Scientifique de France.

Parisot, G. H., Essai sur la Nature des Orbites des Comètes, 8vo. *Paris*, 1867 — The Author.

The Academy.	Pays Bas, Rapport fait à l' Académie Royale des Sciences des, 8vo. *Amsterdam*, 1868
The Imperial Academy.	Petersburg, St., Bulletins de l' Académie Imp. des Sciences, tomes x., xi., 4to. *St. Petersburg*, *v. d.*
The Imperial Observatory.	———— Jahresbericht am 20 Mai 1866, dem Comité der Nicolai Hauptsternwarte, vom Director der Sternwarte, 8vo. *St. Petersburg*, 1866
The Philadelphia Academy.	Philadelphia, Academy of Natural Sciences, Proceedings, 4 parts for 1867, 8vo. *Philadelphia*, 1867
The Author.	Plantamour, E., Des Anomalies de la Température observées a Genève pendant les quarante années 1826, 1865, 4to. *Génève*, 1867
	Pogson, N. R., Popular description of the Total Eclipse of the Sun Aug. 18, 1868, prepared at the Madras Observatory for the Asylum Press-Almanac, 8vo. *Madras*, 1867
——	Quetelet, Ad., Météorologie de la Belgique comparé à celle du Globe, 8vo. *Bruxelles*, 1867
——	———— Observations des Etoiles filantes périodiques de Nov. 1866, 8vo. *Bruxelles*, 1867
——	———— Bolide observé le 11 Juin, 1867, 8vo. *Bruxelles*, 1867
——	———— Des lois Mathématiques concernant les Etoiles filantes, 8vo. *Bruxelles*, 1867
——	———— Deux lettres de Charles Quint à F. Rabelais, note de, 8vo. *Bruxelles*, 1867
——	———— Sur les Etoiles filantes périodiques du mois d'Août 1867, et les orages observées en Belgique pendant l'été de 1867, 8vo. *Bruxelles*, 1868
——	———— Etoiles filantes du milieu de Nov. 1867 et état de l'atmosphère à la même Epoque, 8vo. *Bruxelles*, 1868
The Radcliffe Trustees.	Radcliffe Observatory, Astronomical and Meteorological observations made at the, in the year 1864, 8vo. *Oxford*, 1867
The Royal Institution.	Royal Institution, Proceedings, Nos. 45 to 46, 8vo. *London*, 1867, 1868

Royal Society, Philosophical Transactions, vol. clvi., part 2, 167, 1, 2, 4to. *London*, 1866 — The Societ[y]

———— Proceedings, Nos. 94 to 101, 8vo. *London*, 1867–68 — ——

———— Catalogue of Scientific Papers, 1800, 1863, vol. i. 4to. *London*, 1868 — ——

San Fernando Observatory, Almanaque Nautico para 1869, 8vo. *Cadiz*, 1867 — The Observ[a]tory at Sa[n] Fernando.

Santini, G., Cenni relativi alle osservazioni stellare postume del fu Prof. Virgilio Trettenero seguite de una relazione del recenti catalogo di Stelle del Sig. Lamonte di Monaco, 8vo. *Venezia*, 1867 — The Autho[r]

———— Notizie intorno agli apparati Magneto-Elettrici per la determinazione delle Longitudini Geografiche con la descrizione dell' apparato dell' Osservatorio reale di Greenwich, 8vo. *Padova*, 1867 — ——

———— Delli interpolazione e quadrature meccaniche per gli usi Astronomici, 4to. *Venezia*, 1866 — ——

Scarpellini Caterina, Catalogo degli Uranatme (ossia stelle Cadentio) osservati alla privata stazione Meteorologica di Roma negli anni 1861, 2, 3, 4, 5, 6, 7, folio. *Roma*, 1868 — Signora Sc[ar]pellini.

Schäfli, Prof. L., Lösung einer Pendel-aufgabe, 4to. *Bern*, 1867 — The Auth[or]

Schmidt, J. F. J., Uber Feuer Meteore, 1842 bis 1867, 8vo. *Wien*, 1867 — ——

Secchi, Padre, Météorologie et la Météorographie à l'Exposition Universelle, 8vo. *Paris*, 1867 — ——

———— Sugli Spettri prismatici delle Stelle fisse, 4to. *Firenze*, 1867 — ——

———— Catalogo delle Stelli di cui si e determinato lo spettro luminoso all' Osservatorio del Collegio Romano, 8vo. *Parigi*, 1867 — ——

———— Sull' epoca vera e la durata della cecita del Galileo, 8vo. *Roma*, 1867 — ——

The Smithsonian Institution.	Smithsonian Collections, vols. vii., viii., 8vo. *Washington,* 1867
——	———— Report for 1865, 8vo. *Washington,* 1866
The Author.	Stockwell, Jno. N., A Treatise on the Secular Equations of the Moon's Mean Motion, 8vo. *Cambridge, U.S.* 1867
——	Struve, O. von, Uber die Sirius-satelliten, 8vo. *St. Petersburg,* 1867
——	———— Tabulæ quantitatum Besselianarum pro annis 1865 ad 1874 computatæ, 8vo. *Petropoli,* 1867
The Sydney Observatory.	Sydney, Meteorological Observations made at the Government Observatory under the direction of G. R. Smalley, July 1867 to Feb. 1868, 8vo. *Sydney,* 1867 1868
The Author.	Sykes, Col., Storm Warnings, their importance and practicability, 8vo. *London,* 1867
The Turin Academy.	Turin, Memoria delle Reale Academia delle Scienze di Torino, serie secondo, tomo xxii., xxiii., 4to. *Torino,* 1865
——	——— Atti, delle 1866, 1867, 8vo. *Torino,* 1866, 1867
The Observatory.	United States, Naval Observatory, Astronomical Observations made at the, in the years 1851, 1852, 4to. *Washington,* 1867
——	———— ———— Observations and Discussions on the November Meteors of 1867, 8vo. *Washington,* 1867
The U.S. Navy Department.	———— Navy Department, List of the reported dangers to Navigation in the Pacific Ocean, whose positions are doubtful, or not found on the Charts in general use, 8vo. *Washington,* 1866
The Society.	Victoria Royal Society, Transactions and Proceedings, parts 1, 2, vol. viii., 8vo. *Melbourne,* 1867–68
The Imp. Academy.	Vienna Denkschriften der Kaiserlichen Akademie der Wissenschaften, vol. xxvi., 4to. *Vienna,* 1867
——	——— Sitzungsberichte, Band 54, 55, 56, 8vo. *Vienna,* 1867

Wackerbarth, A. F. D., Femställiga Logarithm Tabeller, 12mo. *Upsala*, 1867 — The Author

Wolf, Dr. R., Astronomische Mittheilungen, Sept., Oct., Nov., 1866, 4to. *Zurich*, 1866 — ——

—— —— Wilhelm Herschel, Ein Vortrag gehalten den 28 Feb. 1867, auf dem Rathhause in Zurich, 8vo. *Zurich*, 1867 — ——

Zoological Society, Transactions, vol. vi., parts 1 to 5, 4to. *London*, 1866–7 — The Zoological Society.

—— —— Proceedings, 1866, 1867, parts 1, 2, 3, 8vo. *London*, 1866–67 — ——

Zurich, Vierteljahrsschrift den Naturforschenden Gesellschaft, 9th, 10th, and 11th years, 8vo. *Zurich*, 1864–66 — The Society Turin.

Miscellaneous.

Various Charts and Plans from the Depôt Gen. de la Marine, Paris.

An Engraving of the Nebula of Orion, by Prof. Secchi.

Spectra of Stars, by Mr. Huggins and Dr. Miller (authors.)

Universal Instrument by Short, date about 1749, Mr. Baker.

Books purchased with the Turnor Fund.

Kepler, Joh., Opera Omnia, vol. vii., 8vo. *Frankfurti*, 1868

Lindenau, Bernardo de, Tabulæ Veneris novæ et correctæ ex Theoria Gravitatis clarissimi de la Place et ex Observationibus recentissimis in Specula Astronomica Seebergensi habitis erutæ, 4to. *Gotha*, 1810

——————— Tabulæ Martis novæ et correctæ ex Theoria gravitatis clarissimi de la Place et ex Observationibus recentissimis erutæ, 4to. *Eisenberg*, 1811